HOME-FARM POWER AND LIGHTING

Automotive service Digest.

HOME—FARM POWER AND LIGHTING

A BOOK OF
HELPFUL INSTRUCTION

On the Installation, Use and Repair of the Internal Combustion Engine, Combined With Suitable Electrical Equipment. It Covers the Complete Electric Light and Power Plants for the Home and Farm.

89 Illustrations and Diagrams.

BY THE EDITORIAL STAFF
OF THE
AMERICAN AUTOMOBILE DIGEST

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Light and Power.

WHEN the world began there was light. Through the centuries our sun, with myriads of stars which are the suns of vast solar systems, has given us the glory of our universe. From that great source comes also the power and energy from which we create what is known as artificial or transformed light—the most magnificent accomplishment of the age. Man's ingenuity has devised ways in which to harness the great forces of nature. Elements are made to unite by the ingenuity of mankind. To those who have delved into these hidden mysteries this book is dedicated.

PREFACE

THIS volume has been prepared by the editorial staff of the *American Automobile Digest,* in response to many inquiries requesting data on the installation and use of the internal combustion engine, combined with suitable electrical equipment.

It is not intended to be a complete treatise on either subject, since both are very broad, but the object of the authors has been to compile a volume which would give the fundamental principles of operation, and the attention required to obtain maximum efficiency.

It is with the hope of increasing the interest in auxiliary power plants, so very desirable in many localities, and reducing the trouble ordinarily encountered in the operation of such power plants, that this book is offered.

The publishers take this occasion to express their appreciation for the kind assistance lent by many manufacturers in supplying data and illustrations.

EDITORIAL STAFF,
AMERICAN AUTOMOBILE DIGEST.

Part I.

The Internal Combustion Engine.

INTRODUCTION.

HOME AND FARM POWER AND LIGHTING refers particularly to the auxiliary power plants which are necessary in the country home and on the farm. It covers the complete electric light and power systems and their operation. The equipment available for this purpose is a combination plant, incorporating an internal combustion engine, electric generator and storage batteries. The engine forms the source of power which drives the generator, the latter generating the electric current to maintain the batteries in a fully charged state and supplying current direct where required. The batteries are generally of ample capacity to provide current for utility purposes, such as may be required in the home or about the farm. The engine can also be used to drive line shafting for the various purposes, such as operating cream separators, pumps, churning machines, etc., as shown in Fig. 1.

As a direct result of the rapid increase in the cost of living, inventive genius has been taxed to the utmost in an attempt to devise new ways of gaining various ends in order to permit of keeping pace with the trend of events. Efficiency

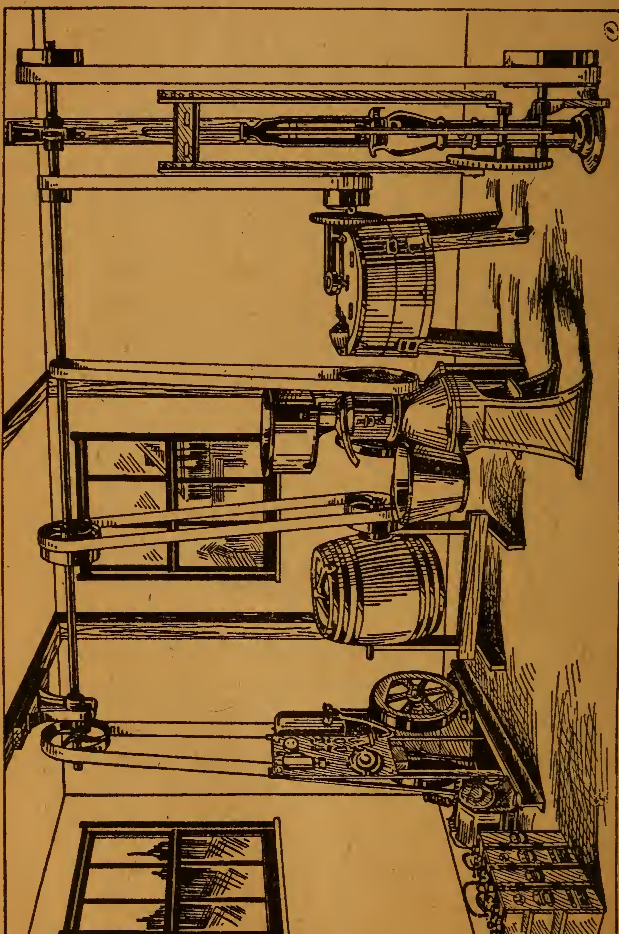


Fig. 1. Showing the usefulness of the internal combustion engine about the country home and farm.

—meaning perfect results and increased output with minimum expense—is the foreword of the age in all walks of life, and only those who give this all-absorbing subject careful thought and study can hope to obtain a place in the front rank of prosperity.

Of recent years many labor-saving devices have successfully applied to the farm and rural home; the old-time hardships have been supplanted, to a considerable degree, by comforts which were formerly only enjoyed by the residents of the large cities.

Most of the auxiliary power plants available have an output of 1 to 3 kw., which would appear to meet the conditions for average requirements in either case. Opinions as to the proper construction vary considerably, and there are no doubt advantages to each construction. In some cases the engine, generator and control are built into a single unit and intended to be permanently mounted, while in others the electrical equipment is built into a unit for rigid mounting, while the engine mounting is portable. In the latter case the engine is bolted to the electrical equipment, which permits it to be used for various auxiliary purposes.

The great majority of engines are of the single cylinder type and follow automotive construction very closely. Water cooling is common, while air-cooling is also popular, and in several cases oil is used as a cooling medium to overcome the freezing difficulty.

Various types of electrical equipment are used, both shunt and compound wound fields are employed in the generators. The lead type storage battery seems to be a favored source for storing the electrical energy of the generator; however, there are several automatic plants available in which the batteries are eliminated.

Compactness and simplicity in construction and operation has been recognized as a necessity, and these are the distinguishing characteristics of all such plants available at present.

In the following chapters the construction of each type of plant is discussed, since it is necessary to have a rudimentary knowledge of how these plants operate and their construction, in order to give the various units the proper care and to make repairs when necessary.

PRINCIPLE OF ENGINE OPERATION.

Two and four-cycle engines.—Multi-cylinder engines.

SINCE the internal combustion engine is practically universally used for lighting and auxiliary power plants, we can readily understand that it would incorporate the various features which have been developed in the motor vehicle engine. The four-cycle engine is practically standard, and while one or two makers supply two-cycle engines, we may assume that the four-cycle engine will eventually become the standard for this class of power plant.

Broadly speaking, any internal combustion engine is a heat engine. Its function is to convert energy in the form of heat into mechanical energy. The engine is generally classed according to its cycle of operation. This cycle of operations is defined as the successive actions of the working fluid of a heat engine upon the piston and of the piston upon the working fluid, commencing when a certain relationship between the two exists and ending with the next recurrence of the same relationship. Thus it is any series of events occurring in succession which go to make up the complete operation.

There are four events which must occur in an internal combustion engine to convert the heat of the fuel into mechanical energy. These, in their sequence, are as follows: intake, compression, expansion, and exhaust. This series of events is called the cycle of operations and may

be accomplished either by providing a power stroke every revolution, which is termed the two-cycle, or by providing a power stroke every other revolution, which is termed the four-cycle type.

The Two-Cycle Type.

There are several different types of two-cycle motors; however, but one is adapted to the class of work covered by this volume, and our discussion will cover this particular one which is termed the three-port type. In this type part of the above sequence of operations is accomplished by making the crankcase air-tight and thus performing part of the work of getting the gas ready to ignite. The sequence of events in this type of motor are as follows: While the piston is traveling upward in the cylinder, it creates a partial vacuum in the crankcase, and when it reaches a certain point it uncovers an intake port in the wall of the cylinder, and through the partial vacuum previously created permits the gas to enter the crankcase. While traveling up the piston was compressing a charge of gas, which had previously entered the cylinder, this is ignited, and as it expands it forces the piston down. As the piston reaches the bottom of its stroke, it covers a transfer port which communicates with the crankcase. This permits a fresh charge to enter the cylinder. Exhaust of spent gases is also accomplished on the down stroke of the piston, as it uncovers a port in the opposite side of the cylinder through which gases escape.

From the above it can readily be understood that when the charge is being compressed in the cylinders on the up-stroke of the piston and before ignition takes place, a fresh charge is per-

mitted to enter the crankcase, and when ignition takes place the gases expand, forcing the piston downward, and as it nears the bottom of its stroke it uncovers the exhaust and transfer ports, which permits the spent gases to escape and fresh gas to enter, after which compression again takes place in the cylinder. Thus all four operations have been completed in two piston strokes or one revolution of the crankshaft.

The Four-Cycle Type.

This type is the most efficient and the logical one to use for all-around utility service. It has demonstrated its efficiency in automobile work and is generally understood by the lay mind. The same operations occur in this type; however, two complete revolutions of the crankshaft, or four piston strokes, are required to perform them. In this type of motor the inlet and exhausting of the gases is controlled by valves, instead of ports in the cylinder wall. There are two general types of valves in use, the poppet type and the sleeve type.

The operation of a four-cycle motor may be described as follows: The piston travels downward in the cylinder, and at some point in the wall of the combustion chamber an inlet valve is located, which at the proper time opens and places the combustion chamber in communication with the carburetor. This is illustrated at *A* in Fig. 2. As this valve opens, the piston has created a partial vacuum in the cylinder, which creates a suction and permits gas to enter. This valve remains open until the piston has passed its lower center, and shortly after the piston starts on its up-stroke it closes, and remains closed during the completion of this up-stroke

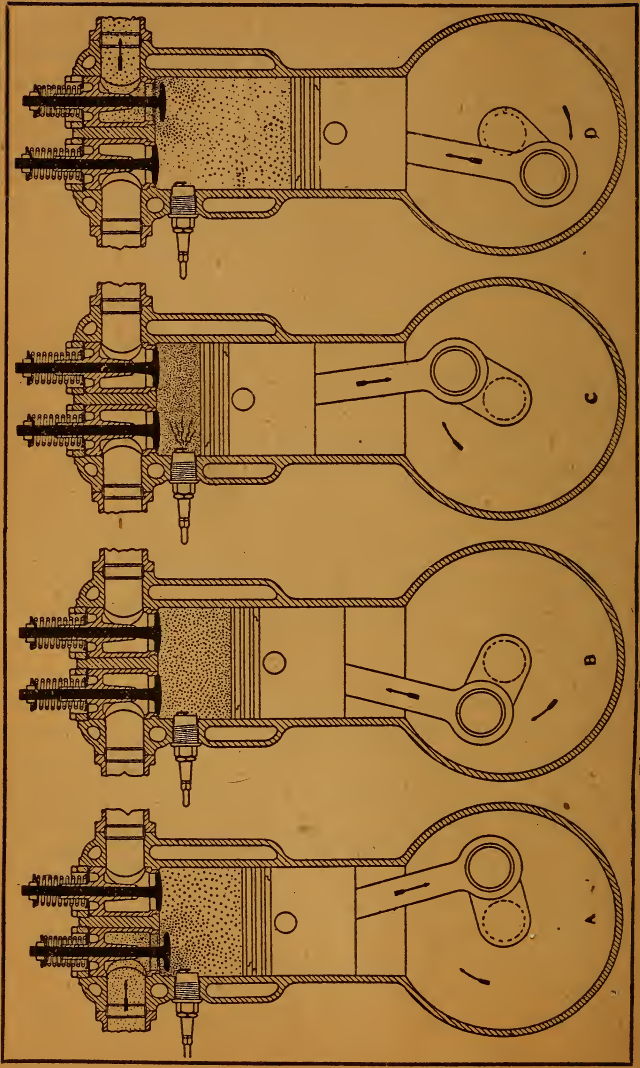


Fig. 2. Cycle of operations of a four-cycle motor.

of the piston. During this up-stroke the charge is compressed within the cylinder and prepared for ignition. So far two operations, intake and compression, have been performed on two piston strokes. The second operation being shown at *B* in Fig. 2.

Immediately after compression the gas is ignited by introducing an electrical spark to occur within the cylinder. This ignition of the gases causes the pressure to rise between four to five times what it was previously. This rise in pressure causes the gases to expand, and thus forcing the piston downward and converting the heat of the gases into useful energy or power. This stroke is illustrated at *C*, Fig. 2, and is generally termed the power stroke.

When the piston reaches the bottom of its stroke, the exhaust valve begins to open and the spent gases escape rapidly. This valve remains open during the next upward stroke of the piston, as shown at *D*, Fig. 2. The piston again starts downward and for a short time both valves remain closed to create the vacuum previously mentioned, permitting the engine to again resume its cycle of operations.

The exhaust valves are always operated mechanically, through gearing from the motor crankshaft, while the intake valves may either be mechanically or automatically operated. In presenting these illustrations, the valves have been placed in the cylinder head purposely, in order to simplify matters.

Both types of motors have their advantages and disadvantages; however, the four-cycle type of motor is by far the most popular, and since it is universally used in the automotive field, it is more generally understood and can be repaired by any auto-mechanic.

Multi-Cylinder Engines.

For small moderate powers a single-cylinder engine possesses the advantages of the simplest possible construction, inexpensive to manufacture and maintain, and more economical in the use of fuel. Since utility power plants do not

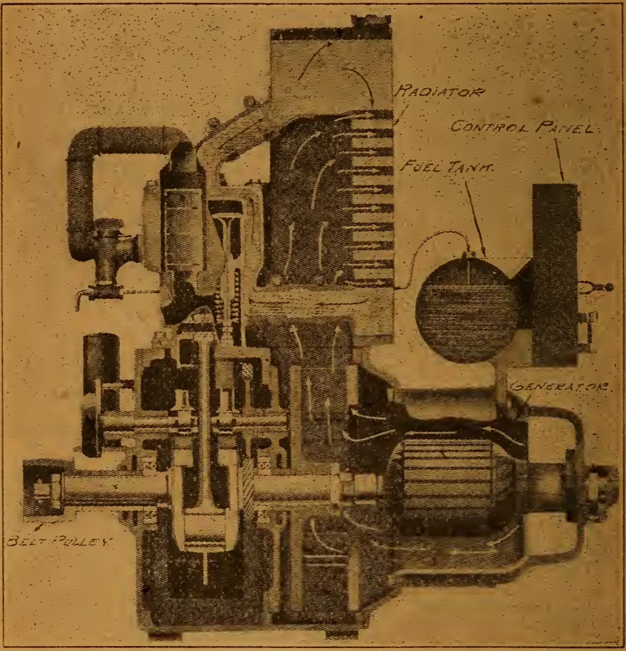


Fig. 3. Internal view of the Everlite single cylinder light and power plant.

require more than four to five horse-power, the single-cylinder engine should be the most popular, which it is. Some few four-cylinder engines are in use; however, the first cost of these is considerably more, while maintenance will also

be quite a bit greater. The turning movement of a four-cylinder engine is much more uniform than that of a one or two-cylinder engine; hence the torque reaction and vibration due to it are much smaller.

However, these advantages are of minor importance in comparison with the features of simplicity and economical operation. The single-

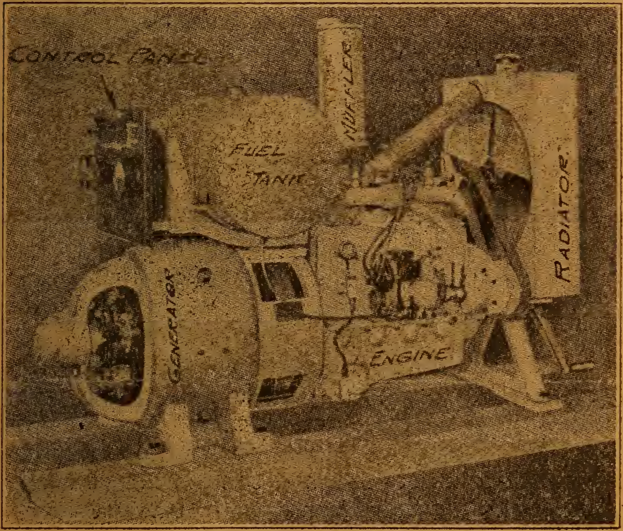


Fig. 4. Four-cylinder light and power plant.

cylinder engine, when properly designed and constructed, will satisfactorily perform the duty of supplying power for auxiliary purposes, and it is justly entitled to its popularity as a utility power unit for the country home and farm.

Fig. 3 shows an interior view of the Everlite plant, which will serve to give a general idea of the simplicity of this type of power unit. The engine is of the four-cycle water-cooled type,

direct connected to the generator. The radiator is mounted on the engine, while the fuel tank and control panel is mounted on the generator. The entire plant is built in a unit and a belt pulley is mounted on an extension of the engine crankshaft.

Fig. 4, which shows an external view of the Langstadt-Meyer lighting plant, serves to give a general idea of a four-cylinder unit mounted on skids. In this case the fuel tank and control panel are also mounted on the generator, while the radiator is mounted on the forward end of the engine. This engine is practically an automobile unit, directly connected to a generator. In the former a fan fly-wheel is used to induce air circulation through the radiator, while in the latter a fan is built into the radiator and driven by a belt from the engine.

A comparison of the two illustrations will readily reveal the simplicity of construction of the single-cylinder unit. In general the fuel and oil consumption per unit of power increases with the number of cylinders, while this is also true of the initial or first cost of these units. Thus it appears that for moderate power requirements the single-cylinder unit has considerable advantages, while for heavy continuous loads the four-cylinder unit will be more desirable.

ENGINE CONSTRUCTION.

Construction of cylinder, piston, connecting rod, crankshaft, etc.—Fuel and ignition systems.

IN elementary form, the construction of an internal combustion engine is quite simple, being comprised of a cylinder, a piston provided with rings operating within the cylinder, a pair of valves which permit proper timing for the entrance and discharge of the gases, a connecting rod for connecting the piston with the crankshaft, a case or housing which supports this shaft, and also a shaft which opens and closes the valves through cams mounted on the latter, and a set of push rods.

From what has been mentioned previously in explaining the cycle of operations, it can readily be understood that the piston travels up and down, forming a reciprocating motion, while the crankshaft rotates in its bearings in order to impart a turning effort to the generator and other units it may be called upon to drive. This conversion of reciprocating motion into rotary motion will be described later.

THE CYLINDER.

The cylinders are usually gray iron castings, provided with water jackets or cooling fins, and have an open and a closed end, as shown in Fig. 5. The inner walls are made very smooth by grinding, lapping or reaming, so that the piston with its rings can slide freely within the cylinder. The closed end forms the combus-

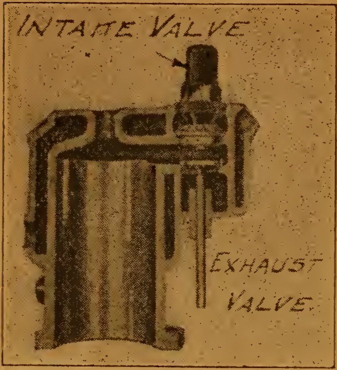


Fig. 5. Sectional view of Cylinder.

tion chamber and houses the valves, which are inserted through small openings in the head. The crank-case is the main housing for all parts and has the cylinder bolted to it. Cylinder construction, of course, varies according to the location of the valves, while the head may also be cast separate and bolted to it.

THE PISTON AND RINGS.

The piston is of the trunk type, being a trifle longer than the diameter of the cylinder. At a point approximately its center, bosses are formed on the inner walls on opposite sides which receive the piston pin, which acts as a hinge for the upper end of the connecting rod. Above this piston pin, three or four grooves are formed which receive the piston rings. These pistons (Fig. 6) are made a trifle smaller in diameter than the cylinder, to compensate for the expansion of the metal, while the rings permit of flexibility so that gases cannot escape by the rings and piston.

Fig. 6. Piston, piston rings and piston pin.

THE CRANKSHAFT.

This is a horizontal steel shaft, carried in bearings inside of a crankcase, and is provided with a number of offsets corresponding to the number of cylinders. These offsets are termed crank-

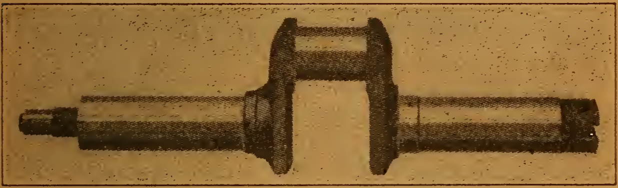


Fig. 7. Crankshaft for a single-cylinder engine.

pins and carry the large ends of the connecting rods. It also carries a fly-wheel, the function of which will be explained later. Fig. 7 illustrates a single-cylinder crankshaft, while Fig. 8 illustrates a four-cylinder crankshaft and piston assembly.

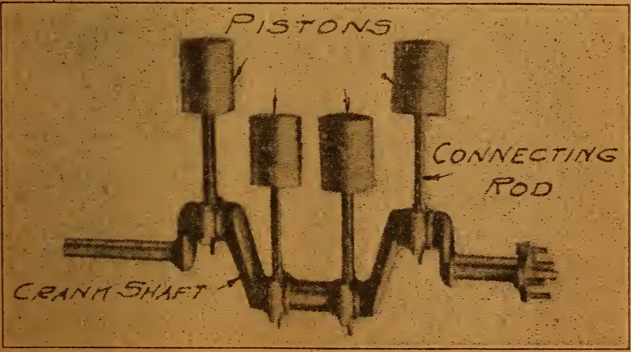


Fig. 8. Crankshaft, connecting rod and piston assembly for a four-cylinder engine.

The Connecting Rod.

The connecting rod forms an intermediate link between the piston and the crankshaft, and its function is to convert the reciprocating motion

Fig. 9. Connecting rod assembled with bearings.

of the piston into rotary motion. This conversion of motion may be described as follows: When the piston is at its top dead center the crankpin is standing vertical; however, as the expanding gases force the piston downward, the crankshaft is constrained and revolves downwardly. The crankpin, which carries one end of the connecting rod, passes through its horizontal position and finally reaches a position vertically below the center of the shaft. This same action of the crankshaft takes place as the piston moves upward, until the crankpin has made one complete revolution. Thus the upper end of the connecting rod reciprocates in harmony with the piston, while its lower end rotates in harmony with the crankshaft. Fig. 9 illustrates this connecting rod assembled with its bearings, while Fig. 10 illustrates it assembled with piston, etc.

Fig. 10. Piston and connecting rod assembly.

The Fly-Wheel.

The fly-wheel is used for storing energy developed during the power stroke, which liberates itself during the idle strokes. In a single-cylinder engine the idle strokes of the piston must be obtained by the energy which is stored in the fly-wheel on the power stroke. For this reason quite a heavy fly-wheel is required.

The Valves.

The valves of a four-cycle engine perform the function of permitting the gases to enter and escape from the cylinders in their proper sequence. The most popular type of valve is known as the poppet valve, although others are used in a few cases. Poppet valves consist of a disc of metal with a stem on one side, which encloses a circular opening in the combustion chamber, being held against its seat by a coiled wire spring.

The Camshaft.

The opening and closing of these valves may be accomplished either automatically or mechanically; however, the automatic feature has never been applied to exhaust valves, being limited to the operation of the intake valve only. The automatic type of inlet valve depends upon the suction of the engine for its operation,

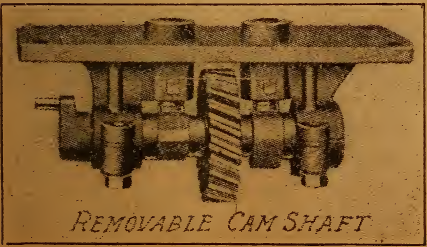


Fig. 11. Camshaft for a single-cylinder engine.

and is held to its seat by a spring which has just enough tension to hold the valve to its seat. In operation the vacuum created in the cylinder overcomes this tension and permits the valve to open. The mechanical operation of the valve is accomplished by the camshaft, which is driven through gears from the crankshaft and in proper time relation with it. The cam causes the valve to raise from its seat while the spring performs the function of closing it.

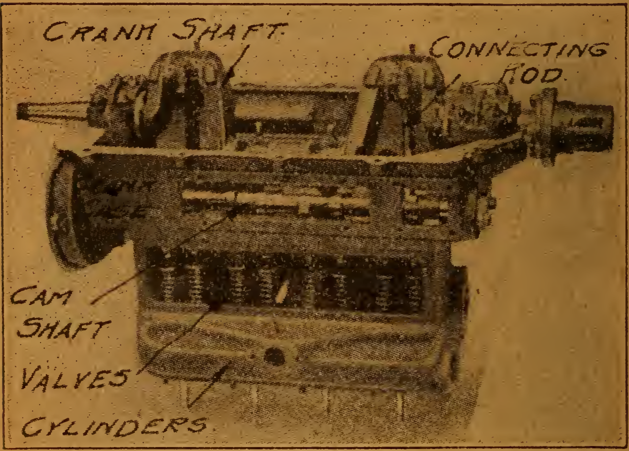


Fig. 12. Camshaft, crankshaft, crankcase and cylinder assembly of a four-cylinder engine.

In this case it is also necessary to convert a rotary motion in a reciprocating motion, as the camshaft revolves, while the valves have a reciprocating motion. However, as no permanent connection is necessary, this becomes quite simple, by providing a push rod, one end of which communicates with the valve stem while the other rests on the cam. This push rod is provided with a suitable bearing so that its relation

with the camshaft can always be maintained. An adjustment is generally provided, so that as little lost motion as is practical may exist between the valve stem and the cam. Fig. 11 illustrates a camshaft and push-rod assembly for a single-cylinder engine, while Fig. 12 illustrates a four-cylinder engine.

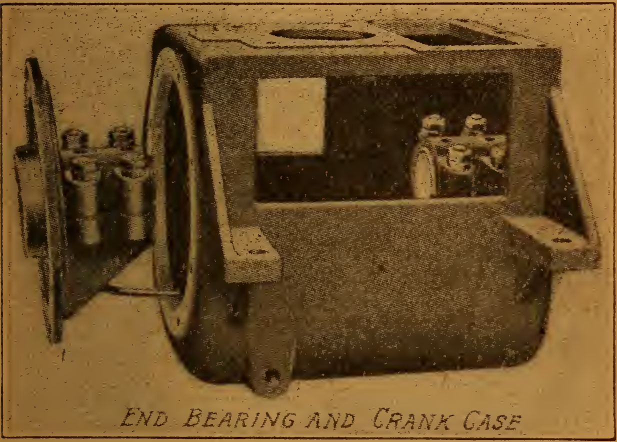


Fig. 13. Borne type crankcase for a single-cylinder engine.

THE CRANKCASE.

The crankcase (Fig. 13) forms the structural part of the motor, carrying the cylinders, crankshaft, camshaft and accessories. It protects these important units from grit and dust and also performs important functions in connection with the lubrication of the motor. The general construction depends entirely upon the design of the engine. There are two general types, the divided and the barrel type, the latter being illustrated.

Classification of Engines.

Engines are generally classified according to the type of valve employed, its location in the cylinder and the number of cylinders. The valve location and type control the entire construction

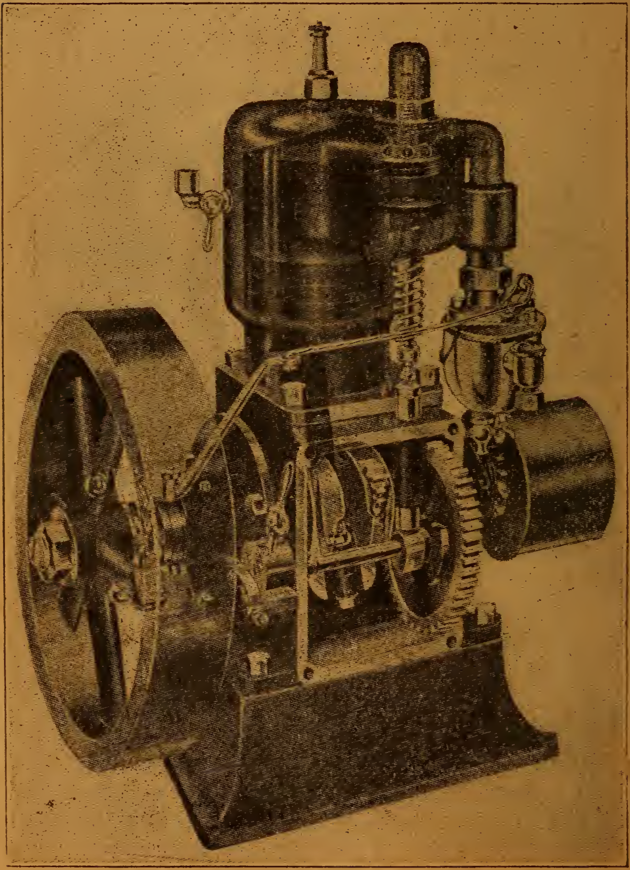


Fig. 14. Cushman 4 H. P. all-purpose engine. This is a single-cylinder, four-cycle type with automatic intake valve.

as well as various factors which enter into its design. The various types classified by valve location and type are as follows:

L-head. A type in which all valves are located side by side in one pocket.

Valve-in-head. A type in which all valves are located in the cylinder head.

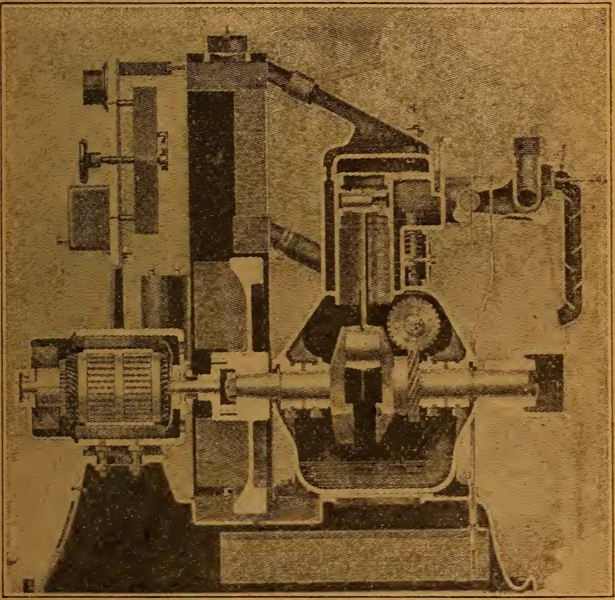


Fig. 15. Litcher-Lite plant. Single-cylinder, four-cycle type, water-cooled by thermo-syphon system.

There is another type which is a combination of the above, in which one valve is placed in a pocket and the other in the head This type is generally used when the intake valve is operated automatically The above covers the poppet valves, while rotating and sliding sleeves may also be used.

In order to cover the general practice of engine construction a number of power plants are illustrated, covering the various types of valves and valve locations. Descriptions are also given which serve to point out the features of each construction and will again be referred to later.

Fig. 14 illustrates the Cushman four-horse-power all-purpose engine. This is an individual

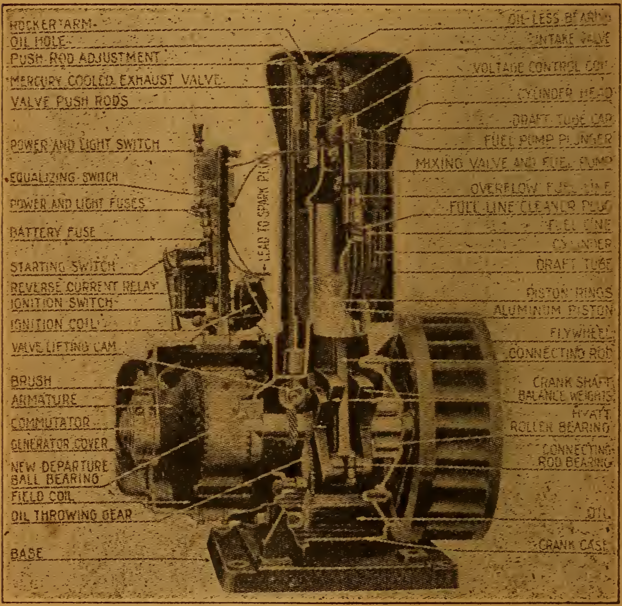


Fig. 16. Delco light plant, single-cylinder type, air-cooled with valves in cylinder head.

engine which can be used for most any purpose by using a belt drive. It is of the single-cylinder four-cycle type. The exhaust valve is operated mechanically, while the intake is of the automatic type. The engine in general follows automotive practice and is water cooled.

Fig. 15 illustrates an internal view of the Litcher-Lite plant, which is also of the single-cylinder, four-cycle, water-cooled type. The cylinder is of the L-head type, and both valves, which are of the poppet type, are mechanically operated. The engine and generator are mounted on a common base and are direct connected. The fuel tank is located in this base, while the oil tank is incorporated in the crankcase. The water

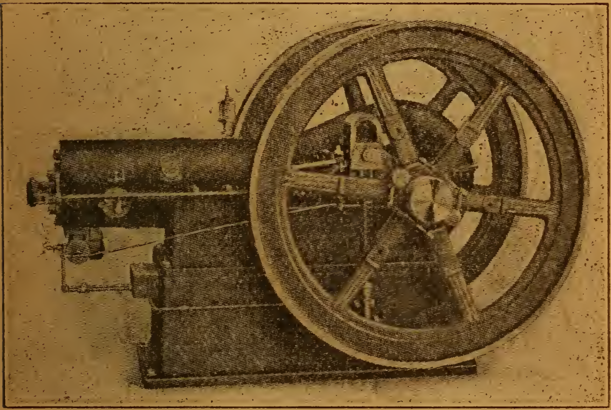


Fig. 17. Lawson horizontal, single-cylinder engine.

is circulated by the syphon system and the flywheel is provided with fan blades to circulate air through the radiator.

Fig. 16 illustrates the Delco engine, which differs from those depicted above, in that the valves are placed in the cylinder head and the latter is air-cooled. The cylinder head which carries the valves is cast separate, while the head and cylinder are provided with vertical cooling ribs. The crankshaft is mounted on anti-friction bearings and is provided with balance weights The ex-

haust valve stem is drilled and the opening filled with mercury, which acts as a cooling agent to keep the valve from overheating.

Fig. 17 illustrates the Lawson horizontal engine, which is also of the single-cylinder valve-in-head type. This engine is designed to operate on kerosene, motor spirits, distillate and other

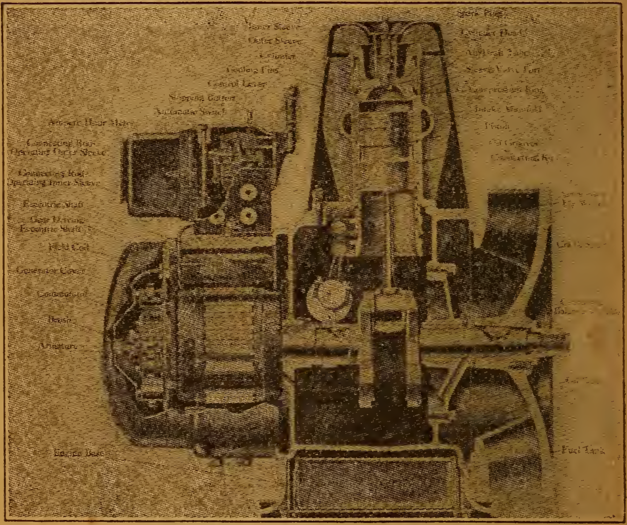


Fig. 18. Willys light plant. Sectional view, showing general construction and sliding sleeves which function as valves.

cheap fuels. It can be made portable by mounting on a suitable truck or skids.

From the above, a good conception of the poppet valve type of engine can be had. Constructional details will vary with the number of cylinders; however, as these are of minor importance, it would be useless to devote space to their description.

Sleeve valves have also been used for utility

power plants and at present two such types are available—the Willys light, which is of the sliding sleeve type, known as the Knight engine, and the Alamo, which is of the rotating sleeve type.

The Willys plant is illustrated in Fig. 18. In this engine the poppet valves are replaced by sleeves which surround the piston and are driven

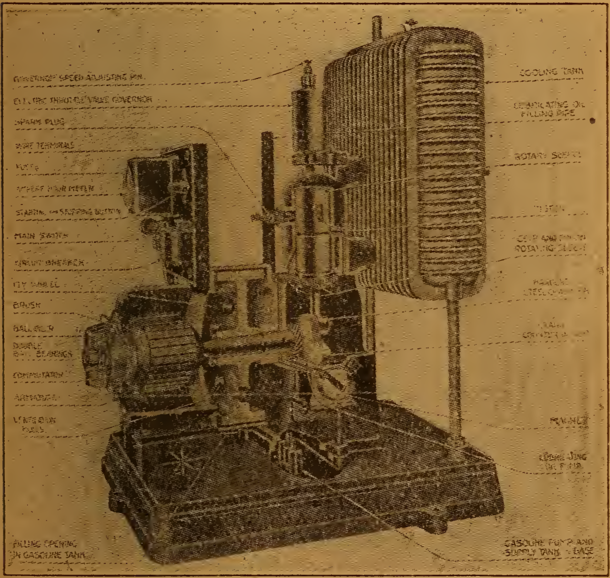


Fig. 19. Alamo, rotating sleeve valve engine. This engine is water-cooled, but a tank with radiating fins is used in place of the radiator.

by an eccentric shaft which is mounted at right angles to the crankshaft. Except for the fact that special attention has been paid to the cooling by the use of an aluminum cylinder head and large cooling ribs, the engine does not differ from standard automotive practice.

In the Alamo engine (Fig. 19) the sleeve does not reciprocate, but is so arranged as to rotate, being driven by means of gears, as illustrated. The rotating sleeve takes the place of the usual cylinder wall and the piston works inside of the sleeve. As the sleeve rotates, port-holes allow for the entrance and exit of the gases.

Cooling Systems.

The cylinder walls must be kept cool for two reasons. One is to permit of proper lubrication, without which the piston could not travel up and down in the cylinder. The second reason is to prevent preignition. If the metal be permitted to heat up to a red heat, the gases will ignite during the compression stroke, previous to the completion of same, and thus cause the engine to reverse.

There are two general types of cooling systems: the direct or air system and the indirect or water system. The air system being termed a direct system, as there is no intermediate transfer of heat from the cylinder walls to the radiating surfaces by means of a cooling liquid. Air cooling is generally effected by cooling ribs, which are cast integral with the cylinder walls, and some mechanical means of inducing air circulation.

The indirect system involves the circulation of a liquid such as oil or water, the function of which is to absorb heat from the cylinder walls and deliver same to a current of air which is passed over the surfaces of a radiator within which the water is circulated. Another method is by using a large tank cast integral with the cylinder or mounted near the engine. Condensers are sometimes provided with the latter.

In a circulating system, the water usually enters at the bottom of the cylinder water jacket, and as it becomes heated it loses its specific gravity, rises, and flows out through the upper manifold to the top of the radiator, where it is distributed to the various tubes which are incorporated in the radiator core. It flows through these tubes in small streams to the lower tank, from which it is again circulated. The radiator tubes are separated by air spaces through which air passes, carrying off the heat units in the water.

The above method of circulating water is a natural circulating system, generally referred to as the thermo-syphon system. In this system the pump is eliminated and the circulating is induced by the heat of the motor. The water, under the influence of heat, sets up a circulation, thus replacing the pump as the moving force acting upon the water. This method of circulation may be used with either a radiator or a tank. In some of the water-cooling systems a pump is used to create a pressure on the water and thus cause it to circulate.

Fig. 3 illustrates a thermo-syphon cooling system incorporating an automobile type of radiator. The fly-wheel is equipped with fan blades and draws air through the generator, forcing it up through the radiator, as shown by the arrows. Fig. 15 also illustrates a thermo-syphon system and fan fly-wheel for inducing an air circulation.

Fig. 19 illustrates another thermo-syphon system, but in this case the radiator is replaced by a large tank which has a capacity of seven gallons of water. The tank is provided with cooling fins for heat radiation. This tank is also provided with a low-water valve which automatically compensates for evaporation. Some of the larger

plants equipped with four-cylinder engines have large radiators which are similar to those used on tractors, having a built-up car and cast tanks.

Figs. 16 and 18 illustrate the indirect or air-cooling system. In both of these designs the cooling is accomplished by a force-draft system through a draft tube and cover surrounding the cylinder. In the Willys unit the air is drawn in through the cap by means of the fan fly-wheel. This permits cooling the spark plug, which is located in the path of the incoming air. In the Delco the draft is through openings in the draft tube, circulation of air being induced by a fan fly-wheel. The majority of power plants are water-cooled, but the above illustrates what can be accomplished by the direct system of cooling, when the subject is given the proper thought.

LUBRICATION.

All parts which rub together under pressure, such as the piston moving up and down in the cylinders, the connecting rod on the piston and crank pins, the crankshaft in its bearings, and all reciprocating and revolving parts, must be efficiently lubricated. Whenever two surfaces are in contact and one or the other is free to move when a force is applied there is present a certain amount of friction, which develops instantly when these surfaces are not properly lubricated.

There are various methods of lubricating utility power plants, and it is very difficult to classify them. In the majority of designs the splash system is used, the oil being splashed on the various working parts by means of some member agitating it. In some cases the connecting rod is used for this, while in others the crankshaft or a special gear is used to distribute oil. Com-

binations of the pressure and splash system are also used, circulation being accomplished by means of a pump driven by the engine.

The Delco and Litcher plants are lubricated by splash; in the former an oil-throwing gear is used, while in the latter an oil dipper is located on the connecting rod. The Willys and Alamo plants are provided with pumps which circulate the oil under pressure to the various bearings and to the cylinders.

In some few cases marine engine practice is followed, in which the cylinder is lubricated from a large oil cup mounted on it and permitting about 12 to 18 drops to enter the cylinder per minute. The circulating within the crankcase being by means of catch basins over the bearings.

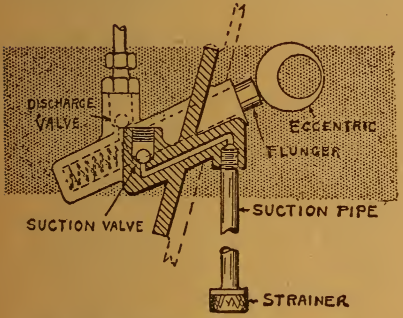


Fig. 20. Plunger type of oil pump.

When oil is circulated by a pump, the plunger type is usually employed. Fig. 20 illustrates this type of pump, which is incororated in the Universal four-cylinder engine. This pump is placed inside the crankcase and is driven by an eccentric from the camshaft. It consists of a barrel carrying a plunger, which is held in contact with the eccentric by a spring. Ball check valves are also incorporated in the barrel. As the plunger moves outward, the barrel volume increases and oil enters through one of the ball check valves. When the plunger is forced inward by the eccen-

tric, this ball valve closes and the oil is forced out through the other ball valve, which had previously remained closed.

GOVERNORS.

Due to the fact that the load on the engine will vary at times, it is necessary to provide some means of controlling the engine speed. This can be done either mechanically or electrically, and both systems are in use. The former acts upon the throttle of the engine, while the latter usually controls the voltage of the generator. The latter is also used to maintain the proper charging rate for the batteries. Some plants are not provided with governors, but depend upon the battery load to hold the speed within reasonable limits.

Mechanical governors are generally set at the maximum speed at which the engine is to operate and are connected direct to the throttle in the carburetor, or they may be so arranged as to operate a compression release.

The mechanical governor provided on the Universal plants is illustrated in Fig 21, and is in effect a mechanical speed-measuring device, so connected to the engine as to cut off the intake when the engine tends to go beyond the predetermined point. It consists of a pair of weights

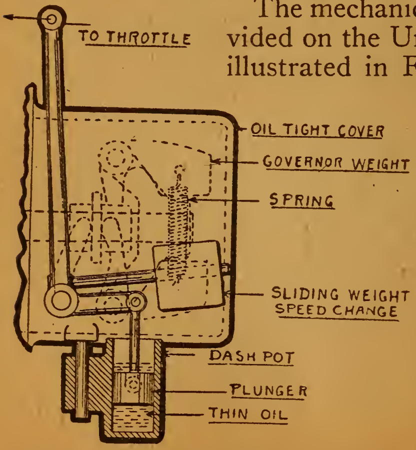


Fig. 21. Mechanical type of governor used on the Universal plants.

which rotate with their shaft and a spring which holds the weights in position As the speed of the engine increases, centrifugal force causes the weights to want to separate and overcome the tension on the spring As the weights open they operate a lever interconnected with the throttle, causing the latter to close, thus strangling the engine and reducing its speed. A weight is provided on the governor, which can be moved a limited distance along its supporting rod, to permit speed changes to a limited degree. It is also used to hold the governor parts against lost motion. A dash pot is provided with a plunger connected to the governor lever, which prevents sudden speed fluctuations.

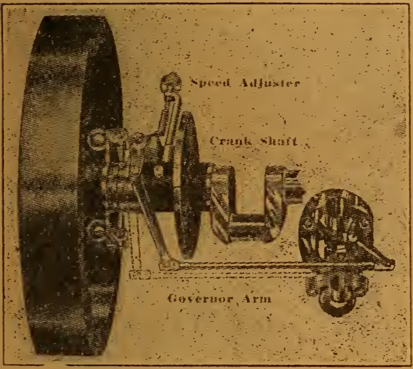


Fig. 22. Cushman mechanical governor built in flywheel, showing connection to carburetor.

Fig. 22 illustrates the Cushman governor and its connection with the carburetor. This governor is built into the fly-wheel and is provided with an adjustment to regulate the speed of the engine. It consists of a pair of weights supported by a collar mounted upon the crankshaft. This collar also supports the governor operating arm, which opens or closes the throttle as the conditions may demand.

In the Novo engine used on the Dyneto plant, the governor is so constructed as to act as a com-

pression relief by holding the exhaust valve open until the engine speed has been reduced to its predetermined limits.

On the Willys plant the engine speed is governed by a fixed air passage which restricts the engine speed to 1100 r. p. m. under load.

The governor used on Delco light plants is of the electro-magnetic type and is shown in Fig. 23. It consists of a coil connected across the generator mains, in which there is a soft iron plunger directly connected to the throttle valve. This valve consists of a plate which covers the opening from the mixing valve into the cylinder head. If the voltage on the generator terminals increases beyond a certain predetermined point for any reason, the voltage coil of the governor becomes stronger and draws the plunger up into it, which results in the throttle valve being partially closed.

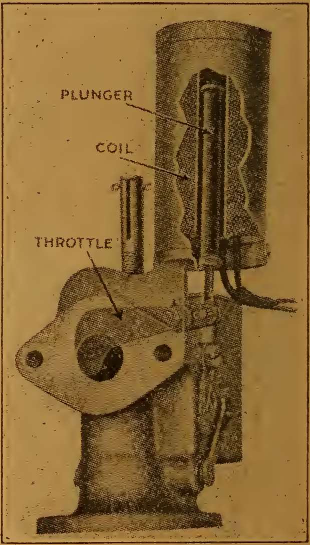


Fig. 23. Electro-magnetic type of governor used on the Delco plant.

When a load is thrown on the generator, its voltage will drop. This results in the coil losing some of its strength, and the plunger will drop to a lower level, thereby opening up the throttle valve. This causes the engine to speed up and to generate more current to take care of the load. When the full load

is on the generator, the voltage will be reduced to such an extent as to permit the throttle to open wide, giving the engine more fuel.

With this system of control, if the battery charge is very low and the engine is then started up, it will charge the battery for a short period at a very high rate, but the battery voltage will quickly pick up and then the charging rate will be reduced. A similar construction is used on the Alamo plant.

The Model J Matthews automatic lighting plant is also provided with an electro-magnetic governor which is similar to the one described above except that it is connected to the throttle by rods. When the generator is carrying the battery load only, the governor controls the speed of the engine so that the proper voltage is maintained to give the batteries the right amount of charge.

If the generator is carrying a partial load in addition to the battery charging load, the amount of current put into the battery is decreased until the point is reached when there is sufficient load on the service lines to keep the plant running continuously.

Fuel System and Carburetor.

The function of the fuel system is to supply the carburetor with an unfailing supply of fuel until the available supply is exhausted. Fuel tanks, as a rule, are mounted in the base of the plant and a pump is employed to raise it to the carburetor bowl. In some few cases a vacuum tank similar to that used on motor vehicles is employed. The capacity of these fuel tanks is generally limited to three to five gallons which ordinarily is sufficient to operate the plant for a considerable number of hours.

Various methods are employed to vaporize the fuel, some being provided with mixing valves, while the convertial type of carburetor is also used. This carburetor or mixing valve converts the liquid fuel into an explosive mixture. The fuel as it is vaporized mixes with a proper proportion of air which supplies the oxygen necessary for combustion. Vaporization of the fuel is generally accomplished by the suction of the motor and heated air. Either will serve the purpose, but as a rule the two methods are combined. The reduced pressure due to motor suction causes vaporization with a lowering of the temperature, and the heated air tends to cause vaporization through a transfer of heat from itself to the liquid. Thus, each of the two methods assist the other. The carburetor or mixing valve is used to serve this purpose, the fuel being fed to this instrument by a suitable means, whence it comes in contact with the heated air as it is being atomized.

Delco Mixing Valve and Fuel Pump.

The fuel tank for this plant is placed underground and connected with fuel pump, illustrated in Fig. 24. A fuel reservoir is cast onto the cylinder head adjacent to the mixing valve, to which the fuel is raised by means of a plunger pump which is operated from one of the valve rocker arms. This pump is of the hollow plunger type, with the ball check valve in the lower end of the plunger. The excess fuel, which may possibly be drawn into this reservoir, returns to the main tank by means of an overflow pipe.

From this constant level fuel reservoir the fuel passes through a small opening or spray

nozzle into the throat of the mixing valve. The air necessary for combustion reaches the mixing valve through a breather tube, and its flow can be regulated by means of an air valve at the top of this tube. The breather consists of two concentric tubes. The inner tube communicates with the crank chamber by means of a check valve, while the outer tube is provided at its lower end with a series of small openings through which air can be drawn in from the outside.

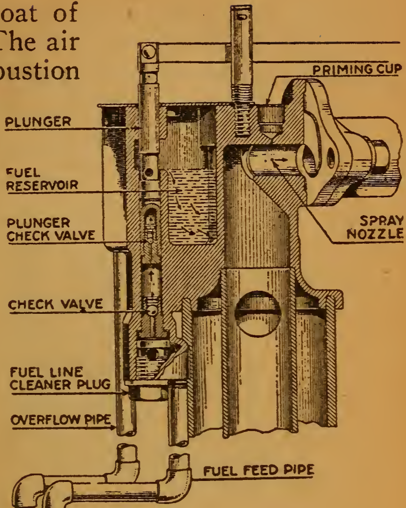


Fig. 24. Delco, fuel system, mixing valve and fuel pump.

Figure 25 illustrates the vaporizing system used on the Willys-Knight plant. It will be noted that in this case provision is also made for drawing air from the crank in addition to that taken in from the outside, while air which is used to

cool the cylinder, is also used. The process of heating is carried still further by means of the intake manifold being bifurcated around the cylinder. Both of the above systems incorporate a feature which is worthy of mention here. Any combustible vapors which are formed in the crankcase will be drawn into the combustion

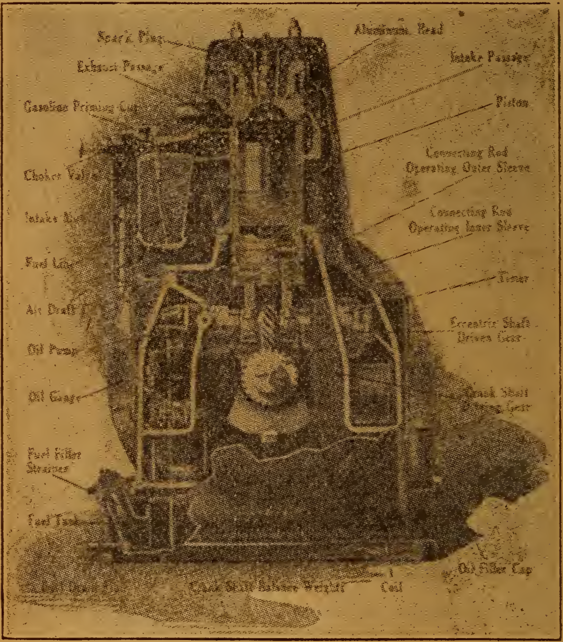


Fig. 25. Willys-Knight vaporizing system.

chamber, where they are burnt. The air in the room where the plant is installed will therefore not be vitiated by smoke from the crankcase.

Fig. 26 shows the conventional type of carburetor which is fitted to a number of power plants. Its principle of operation may be described as

follows: Entering through the tube (*A*) the fuel passes through the float valve (*B*) down into the bowl (*C*). Fuel continues to flow into this bowl until the level gets high enough to raise the cork float (*D*). The rising of this float closes the float valve (*B*) and cuts off the flow of gasoline at the proper level. As the level decreases the float lowers and permits the valve to open. This permits maintaining a constant level of fuel in the float bowl.

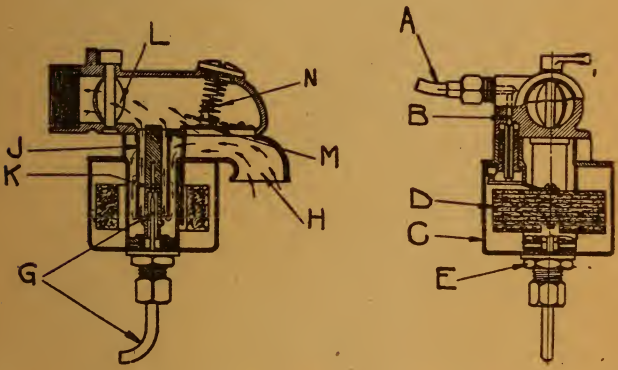


Fig. 26. Conventional type of carburetor.

As the piston of the engine starts down on the suction stroke, it draws in a large volume of air into the intake passage (*H*). This air passes down and around the outside of the tube (*J*) and up inside of this tube. As it rushes past the small holes (*K*) connecting with the needle valve passage, it picks off quantities of fuel and the atomized mixture then passes on to the cylinders through the butterfly throttle valve (*L*). Part of the air drawn in by the engine finds its way past the flapper valve (*M*), which is held to its seat by a spring (*N*). The func-

tion of this spring is to correct the ratios of air entering by the two routes.

When plants are operated on natural or artificial gas it is necessary to provide a special mixing valve for this purpose. Most manufacturers are prepared to supply equipment of this kind when requested, but gas is not generally recommended for fuel.

Ignition.

Ignition systems are practically a fac-simile of the ignition system familiar to all automobile users, both magneto and battery systems being used. It can readily be understood that the fuel which is atomized by the carburetor and then compressed in the cylinder on the compression stroke, must burn in order to expand. Igniting the fuel, therefore, is the function of the ignition. An electric spark is used to ignite the gas, this spark having been previously created.

The magneto is not only a current generator, or a substitute for the battery, but combines all the elements of a complete ignition system except the spark plug. It generates the current, transforms it to a high pressure and distributes it to the cylinder or cylinders, as the case may be.

The structural portion of the magneto consists of permanent magnets of inverted U shape, sometimes referred to as horseshoe magnets. Two such magnets are generally used. The free ends of these magnets are termed the poles, one as the north and the other as the south pole. To these poles are secured soft-iron blocks, known as pole pieces or pole shoes. The magnets and pole pieces are mounted upon a non-metallic base, while the pole pieces are bored out cylindrically to receive the armature, which is of substantially cylindrical form. This arma-

ture consists of a soft-iron core of H-section, and serves to form a bridge for the magnetic flux between the pole pieces and also to carry the winding in which the current is induced. After the core has been properly insulated, several layers of heavy insulated wire are wrapped around it. To the end of this heavy wire the beginning of a very fine silk-insulated wire is connected, which is wound on the core until the

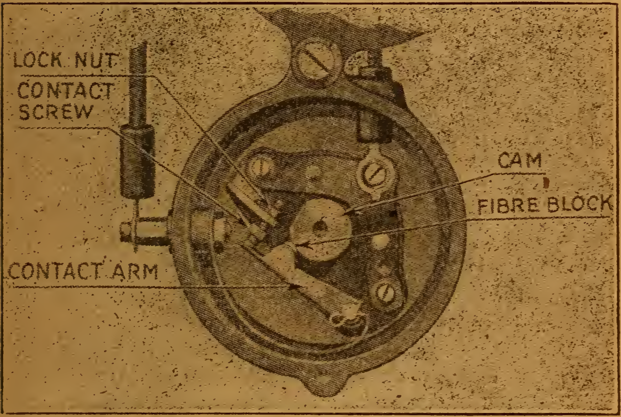


Fig. 27. Conventional type of ignition timer.

slot is almost filled. After an outer insulating cloth is in place, bands are put around the circumference of the armature to hold the wiring in place under high armature speeds.

The heavy or primary winding serves primarily to generate the current and in connection with the fine or secondary winding, also serves to multiply the pressure or voltage to such an extent that it will produce a spark between the spark plug electrodes.

In the other system current is taken from the generator, which is of low voltage, and is

stepped up by a coil at the proper time. This is accomplished by a circuit breaker, while a timer is used for the proper timing of the ignition.

Fig. 27 illustrates the timer used in connection with the battery system. When the ignition system is in operation, current flows from the battery through the heavy winding on the ignition coil, thence to the timer contacts. The timer cam opens and closes the contact points once during every two revolutions of the engine. When the contact points close, current flows through the ignition circuit, which includes the ignition coil winding, termed the "primary."

About the time the piston has reached the end of its compression stroke these contacts are opened by means of the cam. This interrupts the flow of current in the primary circuit, and it is this interruption that causes the ignition current to rush through the secondary winding of the ignition coil and jump the gap at the spark plug.

Details of ignition systems vary greatly, particularly the mechanical features. In some cases the timer and coil are built into or integral with the engine, while in others the coil, switch, etc., are mounted on the control board. Each system has its advantages and disadvantages; the general duty for which the plant is intended generally determines the type of ignition system to be used.

OPERATION, CARE AND MAINTENANCE OF THE INTERNAL COMBUSTION ENGINE.

Removing carbon, valve grinding, timing and adjustment.—Care of cooling, lubrication, fuel and ignition systems.

MOST engines require very little attention when in operation, regardless of the work they may be doing, but in order to function properly they will require a certain amount of attention. An engine should never be started until the cooling tank, oil reservoir and fuel tank supply has been replenished. All dust or grit that may have collected on the engine should be wiped off carefully with waste or cloth; see that all points requiring lubrication have this supply. Owing to the variety of plants in use, it is difficult to outline any definite routine, and it should suffice to say that the instructions given in the instruction book supplied with each unit should be followed very closely. Considerable time and expense can be saved by doing so.

Nothing will add more to the appearance than cleanliness, and by keeping the plant clean you prevent numerous troubles which may be attributed directly to grit and dust which gets into the working parts, such as bearings and adjustments. This cleaning can easily be done with a piece of cloth saturated with kerosene.

Modern utility power plants are practically trouble-proof, but cannot be expected to work satisfactorily continuously without proper care

and attention. The idea that a modern engine requires no attention, aside from an occasional replenishment of oil, water and fuel, is erroneous. No particular skill or technical training is necessary to maintain the engine economically; but it is advisable to follow a systematic course of inspection and care. If the plant is inspected once a week, much time and annoyance will be saved, and it will not be found necessary to lay up the engine at regular intervals, excepting when convenient. It is a good idea to set aside some particular time which will be devoted to the care and maintenance of this unit.

The following items of care are absolutely essential to be assured of continued service:

1. Retarding and removing the accumulation of carbon.
2. Grinding, timing and adjusting valves.
3. Maintaining compression and mechanical condition.
4. Ignition system.
5. Cooling and lubricating system.

These are the important items; however there are many others which will be covered in connection with those given above. Remember that a power unit is nothing but a piece of machinery and that care and attention alone will give the service so much desired. In order for a power plant to give proper service, it must be in good mechanical condition and maintained in this condition.

Removing Carbon.

The accumulation of carbon in the cylinder is a residue product of oils and fuel. Even the best gasoline obtained nowadays deposits a considerable amount of carbon on the cylinder wall, piston and valves; and this, together with the

carbon deposits of lubricating oil, is always a source of difficulty if no provision is made to retard its accumulation.

Kerosene will not remove carbon, but it will dissolve it to a certain extent, and when put into an engine cylinder will loosen this so it can pass out through the exhaust. That is, kerosene will break up the caked deposit. Ordinarily this treatment is termed flushing with kerosene, and this flushing should begin early and be followed up at intervals of about a week.

Open the priming cup, or remove the spark plug and pour a half-tumblerful of kerosene into the cylinder, while the engine is still hot, so that the kerosene will strike the hot metal surfaces and become partly vaporized. This will assist in distributing the kerosene over the entire inner surfaces. This should preferably be done when the engine can remain idle for a number of hours. The above should be done about once a week.

Another plan is to put two tablespoonsful of kerosene into the clinder after each day's work under the conditions mentioned above. Denatured alcohol is also a good decarbonizer. Like kerosene, it should be introduced into the cylinder while the engine is hot and allowed to remain for some hours. When using denatured alcohol, the combustion chamber should be filled, but care must be taken to prevent it from leaking out and evaporating.

The removal of carbon is a necessary part of the maintenance of a utility power plant, and if the above instructions are followed out, carbon scraping will be confined to two or three times a year. To scrape carbon, it will be necessary to remove the cylinder head, if this is detachable, or valve port plug, and to bring the piston to its upper dead center with both valves closed—that

is, on the upper center of the compression stroke. The scraping of carbon deposits can then be done by tools known as carbon scrapers. There are tools of different shapes, bent so as to reach the piston head and cylinder walls. All carbon should be scraped over towards the exhaust valve when the head is not detachable, so as to be able to let it out through the exhaust valve. The various types of carbon scrapers and the method of using them is shown in Fig. 28.

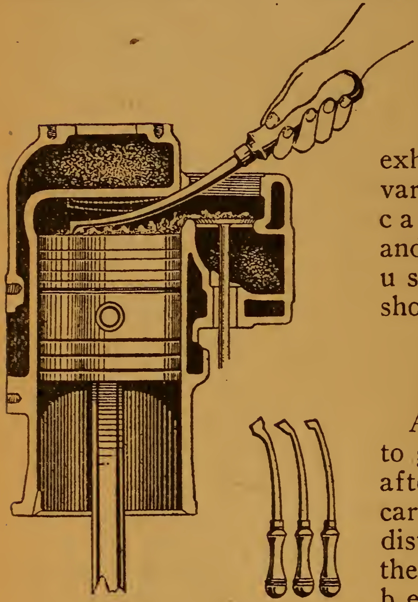


Fig. 28. Method of using carbon scrapers.

Grinding Valves.

A good plan is to grind the valves after scraping the carbon, but never disturb these until the former has been completed. The intense heat in the cylinder and the collection of carbon on their seats causes the valves to leak, and the only remedy is to grind them to a perfect seat in the cylinder. The first step in grinding valves is to remove them from the cylinders. The method to follow can perhaps be best explained by taking each cylinder construction separately. This applies to integral and detachable head cylinders and valve-in-head cylinders.

With integral head it is necessary to remove the valve port plugs and then get the piston to its top position on the compression stroke. This will free the valve so that the springs can be compressed and the retaining members removed.

With detachable heads it is necessary to first drain the water from the cooling system and to remove the cylinder head, then remove the valve springs, as mentioned above. It is best to grind one valve and replace it before the next one is removed.

With valves in the cylinder head it is necessary to remove the rocker arms which operate the valves, and in some cases the exhaust pipe, etc. With a detachable head, the instructions given above should also be followed.

For grinding valves use one of the valve grinding compounds which can be bought prepared and ready to use. Now lift the valve from its seat and carefully clean off all carbon or dirt. Then smear the chamfered edge of the valve with valve-grinding compound. Replace the valve on its seat, and with an oscillating motion turn the valve back and forth on its seat with a screwdriver. Do not turn too long on one place, but keep continually lifting the valve from its seat and replacing it in another position to thoroughly distribute the abrasive material. Also be careful not to put too much pressure on the valve. A good plan is to put a light spring under the valve before putting it in place to grind. This spring will lift the valve clear of its seat when the pressure on the screwdriver is released and prevent the forming of a ring or groove on its seat. Care should be taken that the grinding paste does not reach the cylinder walls or valve guides. It is best to pack the valve ports with waste to prevent this.

If the valve squeaks and sticks when grinding, and a narrow black line appears with the grinding compound, on either side, it will be impossible to obtain a proper seat by continuing the grinding. With a small half-round, fine-toothed file remove the black line, being careful not to scar that part of the surface which does not show the line. Then continue grinding, and the valve will work to a perfect seat.

After grinding the valve for a few minutes, remove and examine it, clean and wipe it frequently; if it is ground properly a light, silvery line will show around the valves. If it is not ground sufficiently, repeat the operation. When the valve grinding has been completed, clean the valve and cylinder carefully with gasoline or kerosene. Use great care to clean out all particles of dirt. When everything is completed, remove the waste from the cylinder and seat the valve with a few drops of oil under the valve and on the valve stem. Then reassemble the various parts as they were removed. In doing this be careful to get all gaskets in place properly.

Unless the valves are warped, as indicated by the grinding compound cutting half the valve only, the operation of grinding consists chiefly of cleaning carbon from the valve and valve seat. The exhaust valve will require more frequent attention than the intake valve. A good way to test for a perfect seat is to draw radial pencil lines around the valve about one-quarter inch apart. Then seat the valve and turn as you did in grinding, and if the valve is properly seated, a portion of all the pencil marks will be removed. Any untouched lines indicate an uneven spot and more grinding is necessary. Fig. 29 illustrates the method of grinding valves when

they are placed in a detachable head; the operation is similar for any other valve location.

The adjustment of the valve tappets, or push rods, as they are generally called, is accomplished in various ways, depending upon the type of adjustment provided. Fig. 30 illustrates the adjustment when valves are placed in the head, in which case this is incorporated in the rocker arm. This adjustment must be made when both valves are completely closed. The clearance allowed between rocker arm and valve stem is usually equivalent to the thickness of a piece of newspaper. Adjustments for valve clearance should be done while the engine is warm; never do this while the engine is cold, as the adjustment will be disturbed after the engine heats up,

Fig. 29. Proper method of grinding valves.

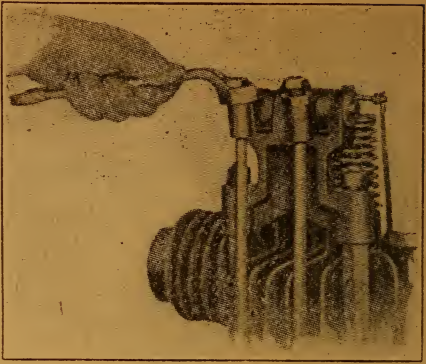


Fig. 30. Adjusting push rods of a valve-in-head engine.

causing the metal to expand. Immediately after valve grinding, start the engine, and even if it does run erratically for some time, this will suffice to warm it up. A good plan to follow is to adjust the exhaust valve first. The clearance between the valve stem and push rod can be tested by means of a feeler gauge or a business card.

Fig. 31 illustrates the method of inserting the card. Loosen the lock-nut provided on the adjusting screw and screw up the latter until the card just begins to bind, then lock the nut securely, so that the adjusting screw cannot turn. In doing this, it is generally necessary to use two wrenches, as the screw must be prevented from turning while the nut is locked.

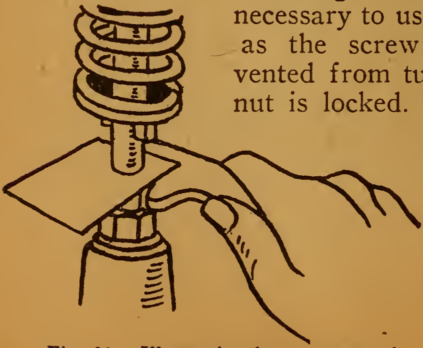


Fig. 31. Illustrating how to use card as a feeler in adjusting push rods.

Valve adjustment should be tested frequently, as the power of the motor is dependent to a consider-

able extent upon the proper seating of the valves.

Valve timing is not necessary unless the engine has been dismantled for a complete overhauling. Fig. 32 illustrates the various parts of the valve mechanism, and if it is necessary to check the valve timing, it is far more economical to have a competent mechanic do this. It is not a difficult undertaking, but the function of the valves and their mechanism must be thoroughly understood.

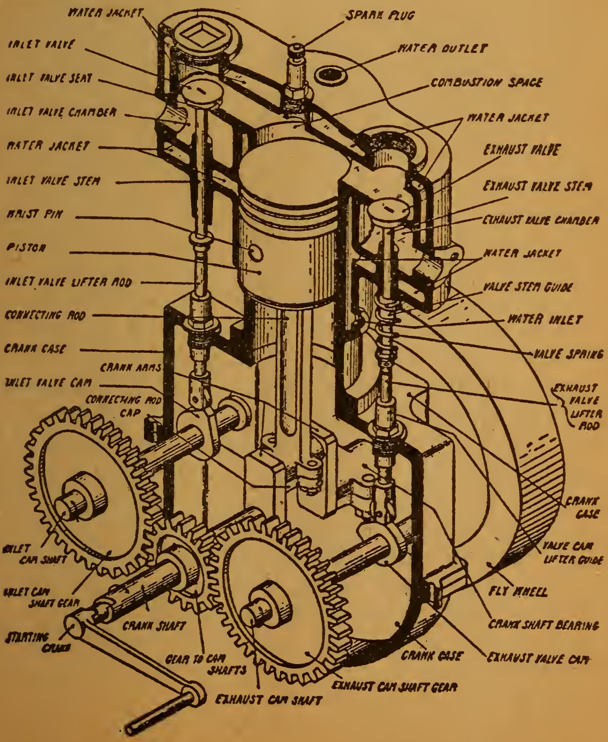


Fig. 32. Sectional view of a single cylinder engine, illustrating the valve mechanism and its relation to other parts.

Maintaining Compression and Mechanical Condition.

Faulty compression can be detected by a loss of power and irregular running. Compression should be tested occasionally, as the operation of the engine depends a great deal upon the compression and upon the expansion when the gas is burning. Improper valve adjustment will cause poor compression, for, when they remain open during the compression stroke, the compression is released. A poor cylinder head or valve port gasket will also release compression. Occasionally the spark plug is defective and permits the gas to escape, and if it is defective it should be replaced with a new one. Compression will also escape if the piston rings stick, due to the accumulation of carbon and the gumming of oil in the piston ring grooves. This can generally be remedied by the kerosene treatment outlined above. The escape of compression can usually be detected by squirting a little oil at any connection between parts. If bubbles show, there is a leak which should be repaired at once.

By mechanical condition, reference is made to all working parts of the engine, which must be maintained in proper condition if the engine is to work efficiently. Part of this feature has already been referred to above in connection with the valves, while the bearings of the engine must also be kept in proper condition. When the engine begins to knock, due to loose bearings, these should be adjusted immediately. All bolts and nuts should be tightened occasionally. Knocking may also be caused by conditions mentioned below; however, if a slight pounding occurs at every revolution of the engine, it is likely to be caused by a loose bearing. A loose piston

or broken piston ring will also cause the engine to knock.

Care of Ignition System.

The ignition system of a single-cylinder engine is very simple, and as a rule will require very little attention, and should not be tampered with, aside from an occasional cleaning of breaker points and the adjustment of the spark plug points.

The spark plug points should be about 1/32 of an inch apart (the thickness of a worn dime). A slight variation from this is permissible; however, when the points are too close together the engine will operate unevenly and will miss occasionally when running at maximum speed. If the gap is too wide the engine will miss when operating on full load at low speeds. Fig. 33 illustrates the method of setting the spark plug and timer points. The spark plug electrodes must be kept clean, and in case of faulty ignition the spark plug insulation should be inspected for defects. It is advisable to have extra plugs on hand as an emergency measure.

As previously explained, the timer contact points open and close the primary circuit of the ignition system, the interruption thus created causes the current to rush through the secondary winding or circuit and to jump the gap at the spark plug. The timer does not require any attention aside from an occasional cleaning and adjustment of contact points. The normal gap between these varies from .015 to .025 of an inch for the different systems, these figures being equivalent to three to five sheets of paper. When these contact points are working properly, small particles of the metal of which they are composed will carry from one point to another, some-

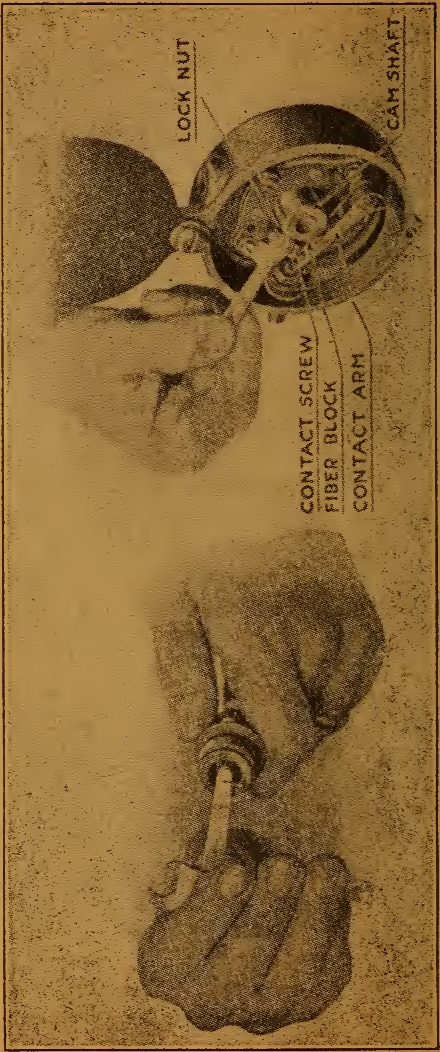


Fig. 33. Adjusting spark plug and timer points.

times forming a slight roughness and change of color. When they do require dressing by reason of the accumulation of dirt, they may be gently filed with a special magneto file, or a fine manicure file, by placing the file between the points and drawing it gently back and forth, allowing the points to hold the file in position.

In case the engine misses and you think the ignition system is at fault, do not jump at conclusions, but start a process of elimination by examining the spark plug and its points. Check the ignition wiring carefully to be sure that all contacts are good and clean. Remove the ignition cable and hold it about ⅛ inch from any metal part of the engine while cranking it. (Fig. 34.) If a spark occurs at the ⅛-inch gap the trouble is not likely to be in the ignition system unless the spark plug is defective. Make sure that wires do not come in contact with any rotating or moving part, which would result in wearing out of insulation and interference with ignition.

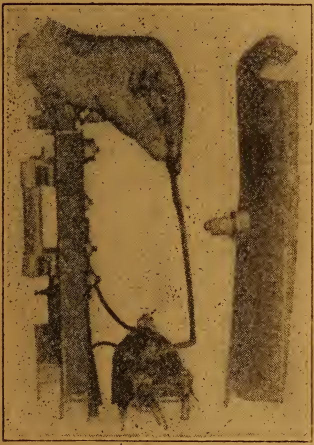


Fig. 34. Photographic demonstration of how to test the spark plug.

Care of the Fuel System.

Dirt will sometimes collect in the carburetor or mixing valve and in the piping leading from the fuel tank, while the fuel strainers will occa-

sionally clog for the same reason. Carburetors can usually be cleaned by removing the needle valve, and if necessary the float chamber, so that the source of trouble can be removed. However, mixing valves are usually provided with cleaning plugs, which can be removed so that a wire can be inserted into the spray nozzle for the removal of dirt, as shown in Fig. 35. As a rule, trouble is usually due to the stoppage of the gasoline flow, especially if the compression and ignition test out O. K. Carburetor flooding is also caused by dirt which accumulates on the seat of the float chamber valve. This can usually be removed by giving the valve a few turns back and forth to flush out the float chamber.

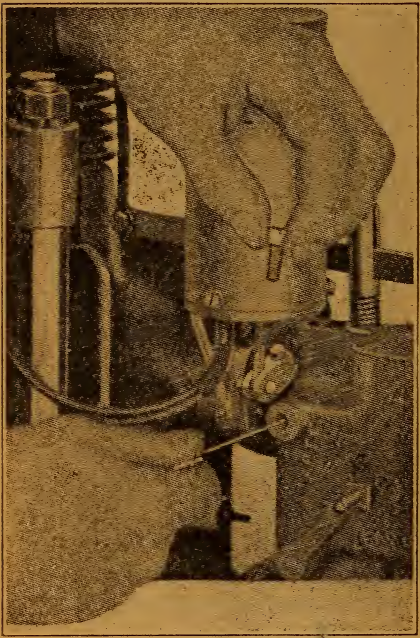


Fig. 35. Showing how to clean spray nozzle in mixing valve.

With any fuel system, except the gravity system, all connections in the fuel line must be kept tight, otherwise leaks will occur and hinder the

action of the engine. When the supply of fuel in the tank is replenished it should be thoroughly strained to prevent any possibility of dirt causing irregular action of the engine. Never tinker with adjustments, until you are absolutely certain of correcting the trouble.

Cooling and Lubricating Systems.

If the engine is air cooled, the cooling system will not require any attention, except that the engine should be so located that it can receive air properly; never cover it with anything, as this would prevent proper cooling.

With the water-cooling system, it is of great importance that the water be soft and free from alkaline, lime or other substances. Rain water is greatly preferred whenever obtainable. This is particularly true if the conventional automobile type of radiator is used. Alkaline, lime and other substances which are present in hard water fill up the radiator cores and water jacket until circulation is interfered with or stopped entirely. Should this ever occur, it will be necessary to remove the deposit. If a cooling tank is used, it can sometimes be removed with a solution of No. 8 acetic acid water, using about one part acid to two of water. Allow this to stand for a few hours, then drain and wash out thoroughly.

Cooling tanks should not be filled completely, as space must be allowed for the vapor, while a sufficient supply should always be provided to insure proper circulation. If there is any possibility of freezing, alcohol or some other nonfreezing solution should be used, such as are generally recommended for automobiles. Another precaution is to drain the cooling system when the engine is to remain idle.

The entire cooling system should be drained and flushed about once a month and replenished with a fresh supply of water. Difficulties due to overheating are sometimes due to the cooling system; the water supply may be low or the flow of water may be stopped.

Positive lubrication is most essential for the successful operation and longest life of any machine, since this is directly dependent upon the life of the bearings and working parts. Good gas engine oil must be used; never use steam cylinder oil. The best oil will be found the cheapest.

Lubricating oil is generally carried in the

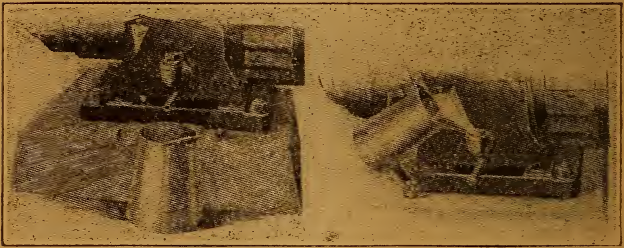


Fig. 36. Draining and refilling crankcase with lubricating oil.

reservoir formed by the crankcase, and generally contains sufficient oil for a number of hours. Most plants are provided with gauges to show the amount of oil in the case, or with oil level corks which act as tell-tales. The oil supply should be kept up to the proper level daily, by adding fresh oil. Fig. 36 illustrates the general provision for filling or draining the oil.

Various recommendations for replacing the oil are given, varying from eight hours to three months; however, when the oil turns black it should be drained and replaced with fresh oil. When this is being done it is a good idea to fill

the reservoir with kerosene, so that dirt which may have accumulated will be washed out. Keep pump and filler strainers thoroughly clean.

Various other parts of the engine, such as rocker arm and exposed bearings, will require lubrication daily if good results are expected. Lubrication oil is as important to the engine as food is to the human body; without it they cannot function properly.

Owing to the variety of systems in use, it is suggested that you consult your instruction book and heed the advice of the maker of the engine. Considerable effort has been made to provide an efficient system of lubrication, and excellent results will be obtained by carefully carrying out the instructions.

In order to assist in locating troubles and to diagnose any irregularities of operation, a trouble chart has been appended. In this an attempt has been made to diagnose troubles in the simplest possible manner. However, you are cautioned to consider these carefully. Never jump at conclusions, for the trouble may be caused by a number of things.

In general, the best advice is to leave all parts of the engine alone until you have carefully thought out where the trouble probably lies and what is causing it. This can be clearly and accurately done by the most inexperienced man if he will only bear in mind and trace out the three lines—compression, ignition and mixture.

Trouble Chart for Internal Combustion Engine.

Engine Will Not Start Firing.

This may be caused by:

1. Fuel tank empty.
2. Fuel lines clogged.
3. Fuel pump not working.
4. Broken or leaky spark plug.
5. Disconected ignition wire.
6. Out of oil. (Indicated by knocking in motor, followed by a stop) causing dry cylinder.
7. Bearings seized, due to lack of oil.
8. Water in fuel.
9. Engine very cold.
10. Breaker points not separating properly.

Engine Misses. Caused by:

1. Faulty spark plug.
2. Poor contact of points on breaker.
3. Broken or disconnected ignition wire.
4. Dirt in carburetor or mixing valve.
5. Loss of compression.
6. Water in fuel.

Loss of Power.

1. Lack of oil or water, (engine running hot).
2. Late ignition, (spark retarded too far).
3. Valves not seating properly.
4. Valves remain open due to improper adjustment.
5. Irregular flow of fuel from tank.
6. Improper adjustment for mixture.
7. Engine strangled, due to muffler being clogged.

Engine Knocks. Caused by:

1. Spark advanced too far.
2. Mixture too rich.
3. Loose connecting rod bearing.
4. Crankshaft bearing loose.
5. Loose piston.
6. Loose piston pin.
7. Broken ring.
8. Carbon in cylinder.
9. Too much play in push rods.

Engine Overheats. Caused by:

1. Low supply of water.
2. Lack of oil.
3. Mixture too rich.
4. Spark retarded too far.
5. Carbon in cylinders.
6. Leak in cooling tank or radiator.

THE INSTALLATION AND MOUNTING OF AUXILIARY POWER PLANTS.

Location, foundation, exhaust and muffler connections.—Fuel tank mountings.

LOCATION of the plant will depend upon its general character, the work it is to do and the general arrangement of the units it is to serve. In the majority of cases generators are provided for lighting and in this case power may be had from the engine direct or from electric motors suitably located. In any event select one best adapted for convenience of all purposes.

The plant may be placed in the basement, garage or barn or in any outbuilding that is centrally located, bearing in mind to make the building frost proof, as the water in the cooling system is liable to freeze in extreme weather when the plant is not in operation. It is very desirable to have the plant installed in a central location as regards the area to be served, or in other words, near the main part of the maximum requirements, for in this way the amount of copper wire required for current distribution can be minimized. By this arrangement current can be fed in various directions with minimum resistance.

The basement of the dwelling makes an excellent location where the winters are extremely cold and thus located it offers a splendid opportunity to use the engine for pumping water, churning; operating washing machine, water plant, etc. If located between house and barns the plant will be centrally located and thus afford greater efficiency than if placed in either

the barn or the house; however, ample provision must be made to protect the plant from the weather.

In moving and hauling the plant to its destination great care must be exercised to prevent jolting or dropping, for while these plants as a rule are very rugged, the highly finished working parts can easily be broken or sprung so that they can not function properly.

If moisture is likely to accumulate, all parts should be given a coating of heavy oil to retard the accumulation of rust. Portable power plants should never be permitted to remain outdoors for any considerable length of time. The efficiency of a plant and its life is directly dependent upon the care and protection it receives. This point is not generally understood, for there are many power plants which are totally ruined within a year's service and consigned to the junk pile, when, as a matter of fact, with proper care and protection, they could have rendered efficient service for a period of five years or more.

A careful analysis of light and power requirements will result in a very profitable return, as considerable time and money can be saved through the proper study of operating condition, thus minimizing the care and protection required. In considering the installation of such plants, avail yourself of the assistance offered by manufacturers of such plants, who at all times are ready to lend you any assistance.

Foundation.

The engine must be set upon a substantial base, which is level and properly constructed so that vibration at high speeds will not injure the plant. A good foundation will also add to the appearance of the plant and accessability, as it can be

set at the proper height. There are various methods which may be employed, but in general all manufacturers recommend concrete. If a concrete foundation is built, nothing but the best of material and sufficient quantities should be used to assure the most satisfactory results. Concrete should be allowed three or four days to settle and harden. The form into which the concrete has been poured should be left in position until after the plant has been mounted upon it —this will tend to avoid cracking and chipping. Care should be used to have the foundation true before bolting plant in position, so that there is no undue strain on the engine base. This base is generally made of cast iron, which is brittle and very apt to crack if you draw it into position. The bolts or lag screws should be drawn home gradually, so as to keep the strain equal at all points. There are various methods of anchoring the bolts or lag screws, some recommending pillars be set into the concrete, while others recommend expansion sleeves, similar to that illustrated in Fig. 37. Some also recommend anchoring the bolts directly in the concrete as shown in Fig. 39. It is hardly necessary to go into the details of mixing the concrete, however several different types of foundations are illustrated.

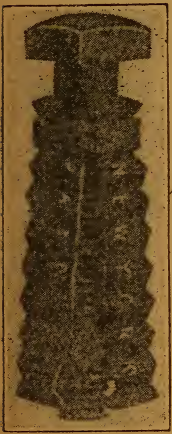


Fig. 37. Expansion sleeve for a lag screw.

The first operation is to build a wooden form of the proper dimensions to fit the plant into which the concrete is to be poured. This is

illustrated in Fig. 38, and if bolts are to be anchored in the concrete this can be spaced by placing strips of wood across the top so as to space the bolts correctly. If wood sills are used these can be set loose in the form in proper position.

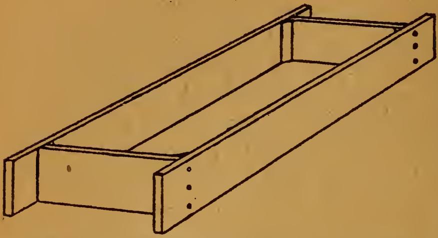


Fig. 38. Wooden form for concrete foundation.

Fig. 39 illustrates a foundation with the bolts anchored in the concrete; however, if expansion sleeves are to be used, holes must be drilled as close to the size of the sleeve as is possible and deep enough to provide a firm anchorage.

Fig. 40 illustrates the type of foundation recommended for several different makes of power plants, in which wood sills are anchored in the concrete, retained by bolts, which are fastened in the latter. This method eliminates the accurate location of bolts and permits using ordinary lag screws. The wood sills also act as a cushion between the engine base and foundation. This also illustrates how to anchor the foundation to the floor. If the foundation is to be placed on a dirt floor, the concrete should

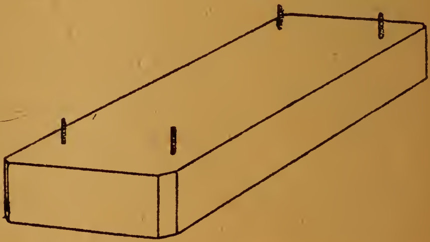


Fig. 39. Concrete foundation with bolts anchored in concrete.

extend down into the ground to good solid bottom and should be made larger at the bottom than at the top.

Exhaust and Muffler Connections.

In order for an engine to operate satisfactorily it is very important that the exhaust be suitably taken care of. The size of exhaust specified by the maker should be used so as not to place any unneccessary back pressure on the engine. All bends of the exhaust pipe should be placed as far away from the engine as possible, and it is of considerable importance to support the pipe in

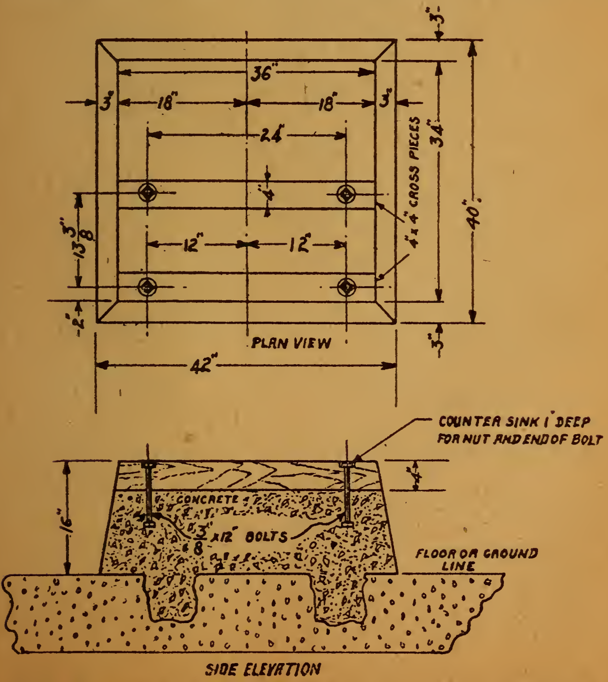


Fig. 40. Concrete foundation with wood sills intended to absorb shocks.

a manner that will allow for expansion and contraction, so as to prevent any strain on the engine when the pipe gets hot.

In all cases, regardless of the location of the engine, it is advisable to run the pipe so that the exhaust may be blown into the open air. On the outside end of this pipe the muffler furnished with the engine should be attached. In order to

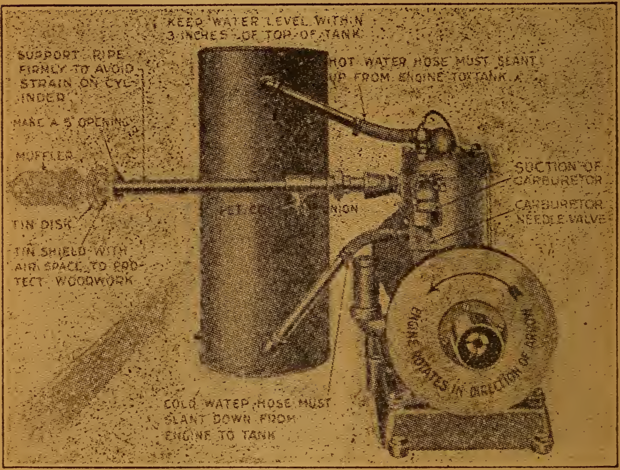


Fig. 41. Exhaust connection with muffler outdoors.

permit the exhaust pipe passing through the building, it is necessary to cut a hole, about a 5 or 6-inch opening, and after attaching the pipe to the exhaust part of the engine, a disc of tin or sheet metal should be slipped over the pipe and fastened to the wall as shown in Fig. 41. This will prevent possible damage due to pipe becoming hot when the engine is running. After the pipe has been installed the muffler can be attached to the outside end of the pipe.

When the plant is installed in the basement or an outhouse near the dwelling, where the noise of the exhaust would be objectionable, practically all of the noise can be eliminated by allowing the exhaust gases to pass through a barrel partially filled with cobblestones, as illustrated in Fig. 42. When this system of muffling the exhaust is being installed, a substantial perforated support must be built

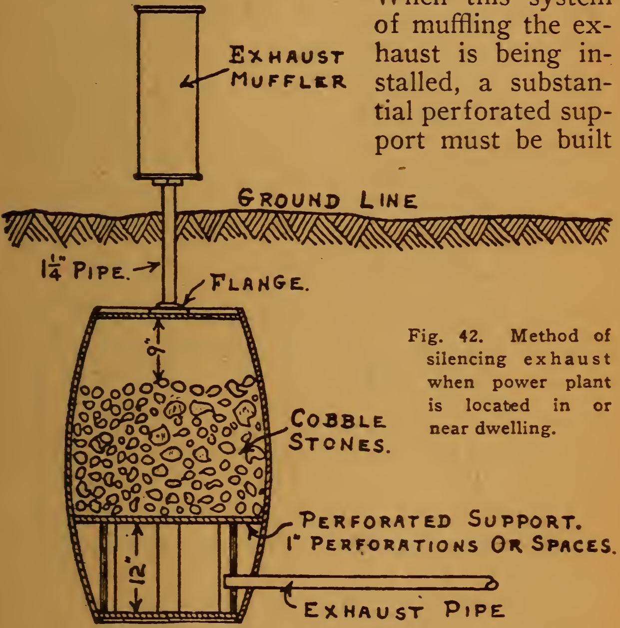


Fig. 42. Method of silencing exhaust when power plant is located in or near dwelling.

into the barrel approximately one foot from the, bottom of the barrel, and the exhaust pipe from the engine must enter the barrel below this support. The barrel should then be filled from the perforated support to within 9 to 12 inches of the top with large cobble stones. A substantial cover should then be placed over the barrel so that no dirt or water can enter and the outlet pipe should be installed to carry the ex-

haust gases to the muffler above the ground line. The barrel should then be entirely covered with earth, leaving only the exhaust muffler above the ground line.

Fuel Tank Mountings.

Power plants, as a rule, are provided with 3 to 5-gallon fuel tanks, which are mounted directly on the engine or generator. While this supply may suffice for some hours, time may be saved by placing a large tank outdoors, underground, and mounting the conventional type of vacuum tank one the engine, which will pump the fuel to the engine. Such an installation is illustrated in Fig. 43.

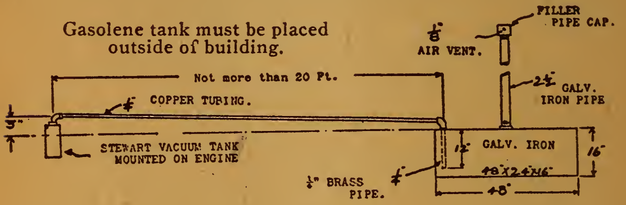


Fig. 43. Method of connecting vacuum tank to outdoor underground fuel tank.

Another installation worthy of mention is that employed on the Sunnyborne plant. In this case a 75-gallon fuel tank made of boiler plate also serves as the foundation for the plant. The tank is sunk into the ground in a 4½-foot hole, which is later filled up with dirt. From the gasoline tank rise four tubular pillars and two wooden beams are secured to the tops of these pillars. A sheet metal skirt, giving the effect of a regulation cast-iron base, is fastened to the beams and extends down level with the ground. The plant is mounted on this skirt, which also supports the sheet metal house enclosing the plant.

PART II.

Electric Generator, Storage Battery and Wiring.

ELEMENTARY ELECTRICITY.

Principle of electrical phenomena.—Electrical equivalents.—Open circuit, short circuit and ground.

WHILE it is not necessary to have an abundance of electrical knowledge, the human being is serious enough to want to know something about electricity and the terms used. Practically all that is necessary is to understand the fundamental principles.

Electricity is a form of energy—a medium for the transmission of power. The distinctive characteristics of electricity as compared with other forms of energy, are that it can be readily and accurately controlled and lends itself to transmission over long distances without undue loss. Various theories have been evolved to explain the exact nature of electrical phenomena; however, a simple analogy may be drawn by considering electricity to be a fluid, and electric current to be a fluid in motion. In other words, electric phenomena may be explained by hydraulic analogies—a method which we shall use here.

Conductors and Non-Conductors.

Any substance will conduct electricity to some extent; some much better than others. There is no known substance which does not offer some resistance to the flow of electrical current through it. Substances such as silver, copper, etc., which offer a comparatively low resistance, are known

as conductors, while substances such as porcelain, glass, fibre, etc., which offer a high resistance to the passage of electrical current, are known as non-conductors or insulators. These insulators serve to keep the current in the conductors which they support or surround. The best insulators in addition to glass and porcelain are mica, hard rubber, ebonite, and silk. A liquid which offers comparatively low resistance is known as an electrolyte, while liquid which offers a high resistance is known as a non-electrolyte.

Hydraulic Anology of Electric Current.

An electric current flowing through a wire may be compared to the flow of water through a pipe line. As water is forced to flow through the pipe by the pressure acting upon it, electric current flows through a wire or conductor due to an electrical pressure or potential created by a battery or mechanical driven generator.

Water, which is acted upon only by the force of gravity, always flows from a higher to a lower level, if free to do so. We say that the flow from one level to the other is caused by the difference in level of these two points. Similarly, when an electric current flows in a conductor it flows from a point of high potential to a point of low potential, and the current flow is due to the difference in potential. Electric potential, therefore, corresponds to water level in hydraulic phenomena. Difference in electric potential is due to an electromotive force. The electromotive force in electrical phenomena corresponds to the force of gravity in hydraulic phenomena. As the force of gravity on any object is measured in pounds, so the electromotive force is measured in volts. In other words, the volt is the unit

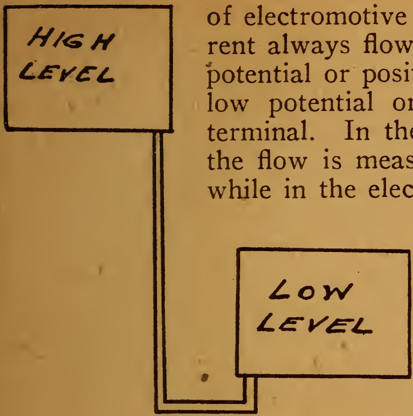


Fig. 44.

of electromotive force. The current always flows from the high potential or positive (+) to the low potential or negative (—) terminal. In the case of water, the flow is measured in gallons, while in the electrical circuit the flow of current is measured in amperes.

Fig. 44 represents two tanks of water, one above the other, communicating by means of a pipe. Since water stands at two different levels in the tanks, water will flow from one to the other. Now, Fig. 45 shows the same tanks connected by a pipe of the same diameter and length, but in this case the difference in level is twice as great. The result is that water flows twice as fast as in the former case. Thus, the rate of flow is directly proportional to the difference in level. This also applies to an electric current, and in any electric circuit, if the electromotive force is varied, other things remaining the same the current will vary in the same proportion as the electromotive force.

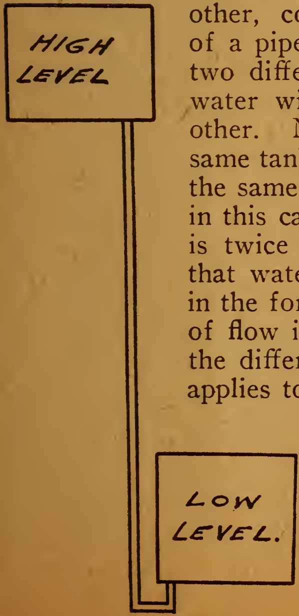


Fig. 45.

Thus, in the two cases above, it was stated that the length and diameter of the pipe remained the same. However, if the diameter of the pipe varied, while the difference in level remained the same, then the rate of flow would also vary, because a change in pipe dimensions would change the resistance encountered by the flowing water. Thus, we can readily understand, if the pipe were lengthened the resistance would be increased, but if the diameter of the pipe were increased the resistance would be decreased. This same theory applies to an electric circuit through which electric current flows. This resistance varies directly as the length of the conductor, inversely as the cross-sectional area of the conductor and inversely as the conductivity of the material of which the conductor is composed. Doubling the length of the conductor doubles its resistance, but if the cross-sectional area and conductivity is doubled, the resistance is halved.

So far we have considered the electromotive force measured in volts, and the flow of current measured in amperes, while we have defined the resistance as an opposition to the flow of current. This resistance is called an ohm. It may be defined as the resistance offered by a circuit to one ampere of current flowing under a pressure of one volt.

Relation Between Current, Voltage and Resistance.

Ohm discovered that in the case of circuits which carry current continuously in one direction (known as direct current circuits), a definite relation exists between the current flowing, the voltage, and the resistance of the circuit. This

relation is known as Ohm's law, namely: The electric current in a conductor equals the voltage applied to the conductor divided by the resistance of the conductor. In other words: Current = voltage ÷ resistance. Transposing to find either of the three, we get:

$$\begin{aligned} \text{Amperes} &= \text{Volts} \div \text{Ohms} \\ \text{Volts} &= \text{Amperes} \times \text{Ohms} \\ \text{Ohms} &= \text{Volts} \div \text{Amperes} \end{aligned}$$

Thus, if two things are known regarding a circuit, such as the voltage and resistance, or the current and resistance, or the voltage and current, the exact relation between voltage, current and resistance can readily be determind by applying the proper formula. The voltage and current are measured by instruments. The voltage by a voltmeter, which is an instrument for measuring electrical pressure and is connected across the source of current supply; that is, from positive to negative (+ to —). The ammeter is an instrument for measuring the flow in amperes and is connected in the circuit so that all current flowing in the circuit must pass through the instrument. There is no instrument for measuring directly the electrical resistance of a circuit, so it must be calculated, by first measuring the voltage and then the current in amperes and dividing the voltage by the current in amperes, as in the formula mentioned above.

Electrical Power.

The Watt is known as the unit of electrical power; in other words, the unit by which is measured the rate at which electrical energy is delivered to an electrical circuit. If a current of one ampere is delivered to a circuit or an electrical device at an electromotive force of one

volt, electrical energy is being expended therein at the rate of one watt, and the rate of expenditure of electrical energy in any circuit or electrical device, in watts, is equal to the product of the current flowing therein, in amperes, by the electromotive force acting thereupon in volts. The watt is a small unit and not very convenient to use, so the kilowatt (K. W.) or 1000 watts, is frequently used. Electrical power units and their equivalent are as follows:

1 Horse-power (H.P.)=746 watts, or .746 kilowatt.
1 Kilowatt=1.34 Horse-power.
1 Kilowatt of power used for 1 hour= 1 kilowatt hour.
1 Ampere of current for 1 hour= 1 ampere hour.

The Series Circuit.

An electrical circuit composed of two or more different wires of perhaps different sizes, lengths and materials, and connected as shown in Fig. 46, is called a series circuit. In this case there is only one path through which current may flow in passing from the positive to the negative terminal. The current of electricity is the same at every point along the different wires, and just as much electricity is returning to the battery in a given time as is leaving the battery in the same time.

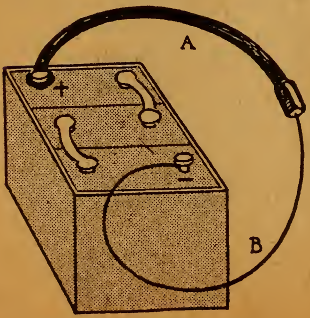


Fig. 46. A series circuit.

The electricity is not used up in the

operation of such a circuit, but its ability to do work is used. The same applies to a series water circuit it which a pump is used to create circulation. There is only one path through which current may flow in passing from the outlet of the pump and return to the pump. The water is not used up in the operation of such a circuit. The circuit is complete and has neither beginning nor end. When the lamps of an electric lighting system are connected in series, the current flowing through the different parts of the circuit at any time is exactly the same.

The Parallel Circuit.

An electrical circuit composed of two or more different wires of perhaps different sizes, lengths and materials, connected as shown in Fig. 47,

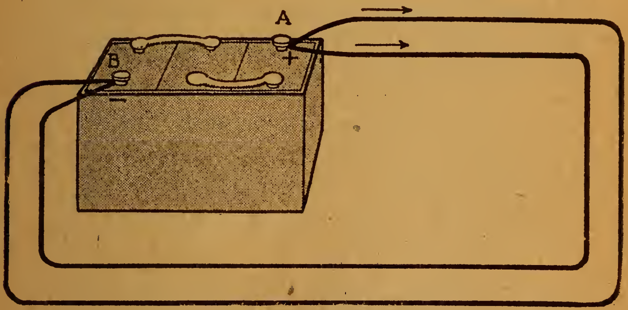


Fig. 47. A parallel circuit.

is called a multiple or parallel circuit. In this case there are as many paths for the electricity to flow through in passing from positive to negative as there are different wires in parallel. Just as much current is returning to the battery in a given time as is leaving it. The quantities of electricity passing through the different paths in

one second or the currents in the different paths of parallel circuits are not necessarily equal unless the resistance of the different paths is the same.

Comparing this with a water system, we would have two pipes connected to a common inlet and common outlet on the pump. In this case, also, just as much water is returning to the pump as is leaving it, but instead of circulating through a single pipe it is circulating through two pipes. The quantities of water passing through the different pipes connected in parallel are not necessarily equal unless the resistances of the different pipes are the same. An electrical system may also be a combination of one or more series and parallel circuits. This is sometimes referred to as a series multiple circuit.

In the series circuit the electromotive force or voltage is multiplied, while in the parallel circuit the current flowing is multiplied, and in the series multiple circuit any combination of the above two factors can be obtained.

There are certain troubles which can arise in electrical circuits, such as an open circuit, a short-circuit and a ground. Any of these interrupt the continuous flow of the current through the path it is intended to flow. These three conditions form the basis of the majority of electrical troubles. A short-circuit is sometimes referred to as a leakage.

An Open Circuit.

Whenever the conducting circuit between the source of electricity to the service or load is broken by a loose connection, a broken terminal or wire, it is called an open circuit. Fig. 48 shows a source and a load; *A, B,* and *C* represent, respectively, the three most common reasons

for an open circuit. In the hydraulic anology this would be equivalent to having a leak in the pipe which permit the water to escape instead of circulating.

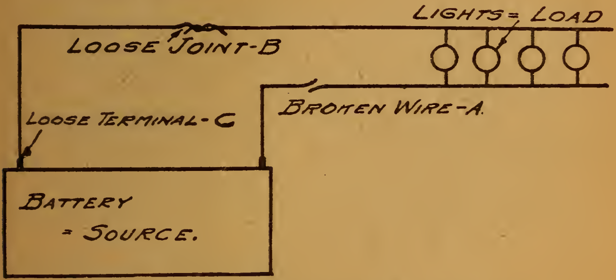


Fig. 48. Diagram illustrating an open circuit.

A Short-Circuit.

Whenever a path for the current flowing between source and load is established in any other way except through its natural course, it is called a leakage or short-circuit. If the resistance of this path is high and only a small current is being passed through it, it is called a leakage, but if the resistance of this path is low or nothing, it is called a short-circuit, as per example, Fig. 49, a piece of iron such as a screwdriver falling across two bare wires.

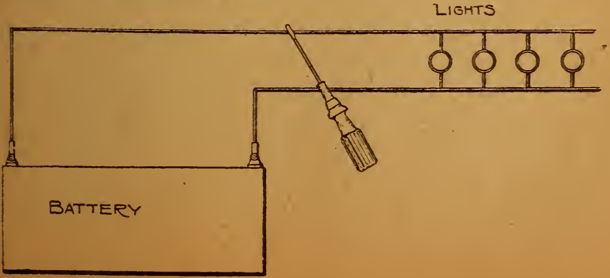


Fig. 49. Diagram illustrating a short circuit.

A Ground.

A ground is of the nature of a short-circuit; it can be a by-passing of current, a leakage or a "dead" short. Fig. 50 illustrates in a general way how a ground could occur. The battery is setting on a damp floor, the switchboard supports are also standing on the same damp floor. Suppose the coil in the iron casing shown has poor insulation, the bare wire will touch the side of

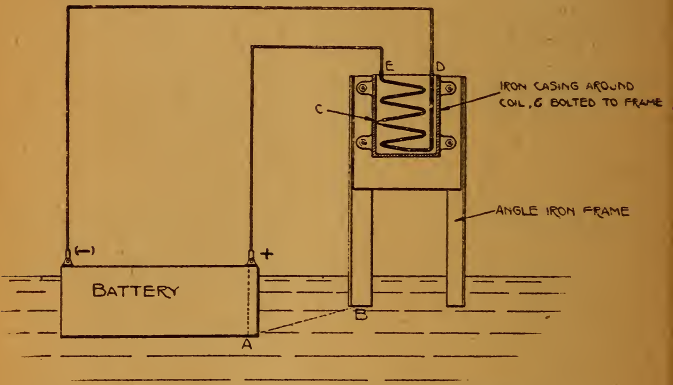


Fig. 50. Diagram illustrating a ground.

the casing and the current will leak from positive (+) on the battery (assuming that the battery has overflowed and acid forms a circuit or path from terminal to ground on floor) to "A" to "B" through the damp floor through angle iron to point "*C*" when the wire in the coil touches the casing (grounded), from "*C*" it flows to "*D*" and to the negative (—) terminal of the battery. The proper path of the current is from the positive (+) of the battery to "*E*" on the coil, and thence through the coil to "*D*" and the negative (—) terminal of the battery.

A careful study of the above features will enable anyone with slight mechanical ability to analyze trouble in an electrical circuit. They form the fundamentals of all difficulties usually encountered in the operation. Small grounds, short-circuits and current leaks are due to some defect in insulation, especially of terminals, connectors, switches, etc. Sometimes these troubles may become the cause of more serious difficulties if they are allowed to go without attention. Wires must be secured against chafing, and therefore should be securely fastened in position.

FUSES.

Fuses are provided in most all electrical circuits, to protect the system from injury in the event of too much current attempting to flow through the circuit. These fuses are generally located on the switchboard, and when the circuit is overloaded they burn out, thus opening the circuit. When glass fuses are used, a burnt-out fuse should readily be detected through the glass tube. When fibre-shell fuses are used, they should show when they are burnt out by a black spot underneath the label on the fuse. Whenever a fuse burns out it is absolutely essential to locate and remove the cause before a new one is put in; otherwise the fuse will burn out again. A blown fuse will result from an overload on the line also, caused by using lights, motors and accessories, that altogether use more current than the system transmits. In replacing blown fuses, be sure to use fuses of proper capacity, and each separate circuit should be provided with fuses. The fuses, as a rule, form the beginning of a process of elimination to locate troubles in electric circuits.

WIRING ELECTRICAL CIRCUITS.

How to install and string the wires, fixtures, switches, fuses, etc.—Making joints.—Outdoor wiring.—Power consumptions of lights and various appliances.

MANUFACTURERS generally recommend that an experienced wireman be employed for wiring the buildings, yet there is nothing difficult about the work. For the benefit of those who may desire to do this work, a few simple instructions, given below, will materially assist in the undertaking. Most anyone can do the job by following the instructions carefully. The underwriters' requirements vary considerably in different localities, and that is the reason why manufacturers recommend the employment of a local wire man, if one is to be had. It is well for one to acquaint himself with these requirements before attempting the work, so as to be able to have his work pass the underwriters' inspection. When the work is done by an electrical contractor, it will not only insure the work being done in accordance with the best and safest practice, but it is really cheaper, as the contractor is really equipped with tools and stock.

After the location of the plant has been decided upon, the first thing to do is to figure out the necessary quality of wire insulators, sockets, switches, etc. Take as an example the wiring of a two-story house of eight rooms, with a cellar and attic, as shown in Fig. 51, and assuming that

the plant is placed in a barn 100 feet from the house. The lighting arrangement to be as follows: One light in the attic, four lights upstairs, five lights downstairs, and one light in the cellar. The attic light and the cellar light are each to be controlled by a switch placed near the attic and cellar stairs. The other lamps are held in key sockets which have self-contained switches.

Always remember that two copper wires must lead to each lamp or switch. These wires must be provided with insulation, that is, kept from any possibility of touching each other, by coverings of rubber compound and braids, and must be held firmly in porcelain insulators or enclosed in iron

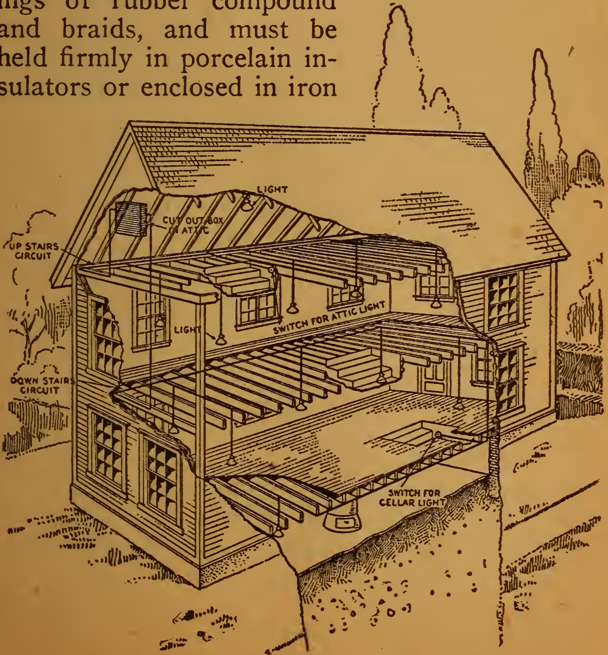


Fig. 51. Sectional view of a dwelling, showing light wiring and lamps.

pipes. This insulation is necessary, because accidental contact between bare metal surfaces carrying electrical current is to be avoided, owing to fire danger, etc.

Selecting for this example a combination of several different insulating systems, we decide to run the wires in porcelain insulators in the attic and cellar, inclosing the wires in flexible woven tubing inside the walls and flooring in the middle of the house wherever insulators are hard to place. A convenient method will be to make a rough diagram or floor plan of each floor, marking on the diagram where the lights are to go.

The two wires from the power plant will enter the house up in the attic, and each will therefore be as long as the distance from the power plant, plus the extra distance through walls and the drop to the plant. Next measure the wire needed for the inside of the house, either using the plan or going over the actual walls and floor with a tape-line or rule. It will be found to be of considerable advantage to divide the wiring into two parts or circuits; for example, one for the upstairs lights and one for the downstairs lights. In this case one pair of wires should be run in the attic from the service switch, passing as near each light on the top floor as convenient. The other circuit controls the downstairs and cellar. The upper circuit is run open above the attic floor on rafters. The lower circuit is run between ceiling and floor above, floor parts being bored and tubed. The individual lights or fixtures will then be connected to wires joined or "tapped" on the same main circuit wires.

Two plans are available for running the wires, either by the tube construction shown in Fig. 52, running the wires through tubes placed in the joists, or by running them parallel with the joists,

as shown in Fig. 53. This serves to illustrate that planning often will save considerable work. Mark the walls and ceiling where each light is to go, and then trace the circuit to determine whether it is as simple as possible and does not require any unnecessary work to install. After the plan has been carefully worked out, estimate the wire and supplies needed, so that you will not be handicapped for lack of material when the job is started.

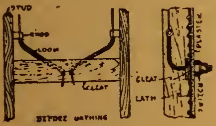


FIG. 55.
METHOD USED FOR WIRING TO SNAP SWITCH OUTLET ON SIDE WALLS.

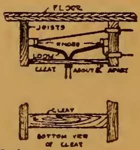


FIG. 54.
METHOD USED FOR WIRING FOR CEILING LIGHT OUTLET.

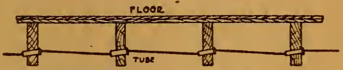


FIG. 52.
TUBE CONSTRUCTION FOR RUNNING WIRE THROUGH JOISTS.

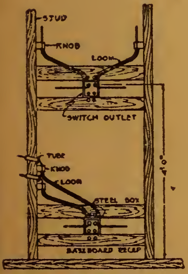


FIG. 56.
METHOD USED FOR WIRING TO FLUSH WALL SWITCH OR RECEPTACLE.

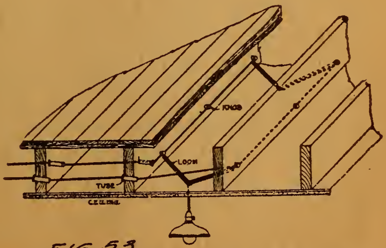


FIG. 53.
METHOD USED FOR MAKING A CHANGE IN DIRECTION OF WIRING BETWEEN CEILING AND FLOOR AND MAKING CONNECTION FOR CEILING OUTLETS.

For lights that hang from the ceiling it is better to take a long, thin bit and bore a hole clear through the ceiling and floor above. These holes will then form guides for opening the flooring. Where the wiring from the power plant comes into the attic through holes bushed with porcelain tubes, they are first connected to a fuse block and then to a switch. This fuse block will serve as a safety guide should the wires in the house become overloaded. In this case, a piece of soft metal (fuse) held in the fuse block will melt and act like a switch, breaking the electrical connection between its source and the danger point.

It is preferable also to use another fuse block on each of the house circuits, as they are of considerable convenience when changes in wiring are being made, as only part of the lights need be turned off. In placing the wire, the cleats or supporting knobs should not be more than 4½ feet apart, unless the wires are run through flexible metal tubes, under which condition it is only necessary to support the wires at each end of the flexible tube. Figs. 54, 55 and 56 illustrate methods of wiring ceiling drop and snap and flush switches.

Wiring the Upstairs Circuit.

The wire is laid in the groove between the cap and base of each insulator, pulled tight, and the nail or screw driven home. Stretch the wires just enough to prevent them from touching against woodwork, metal or pipes. Where wires cross each other, pipes, or pass through holes, they must be insulated in porcelain tubes or flexible tubes, and these must be taped in place to prevent shifting. Begin wiring between the floor joists so as to come as near to each light

as possible, using the holes in the floor as a guide. The main wires only pass near or above these holes; separate pieces of wire are tapped on to actually pass through the holes to the lights. If the wiring is placed in a metal tube it is not necessary to remove floors, but the tube can be pulled under the floor.

The Downstairs Circuit.

Before making the actual connections to the lights of the upper floor, finish the rough wiring by running the downstairs wires. The circuit of two wires will run from the fuse block in the attic down in the wall to the second floor, then along the joists to a point in line with most of the lights. Here boring and porcelain tubes become necessary. The circuit will then go through the tubes and continue across the house between the joists, then down in the wall, and finally to the cellar light and switch. Any lights on the other side of the house from the main wires are reached by wires run between the joists, but tapped onto the main wires.

When wires run inside the walls, encase them in flexible tubes, each wire in a separate piece. This must be measured and put on before the wires are run downstairs. A piece of chain or a sinker attached to a length of fishline may first be dropped down in the wall, its end located downstairs by listening at the baseboard, and a piece of the latter removed, and the fishline can then be used to pull down the wires, which are first attached to the upstairs end.

Finishing and Making Joints.

Where switches are to be put on, as in the case of the attic and the cellar light, run only one wire to the lamp, but the other wire to the

switch. Then run a piece of wire from the switch to the lamp. The switch is to be connected as shown in Fig. 57, to the two ends—one from the main circuit, the other from the lamp. The lamp will be connected to the other circuit wire and to the wire from the switch.

Having finished running the wires and fastened them all tightly under the knobs, join on short pieces of wire to reach down through the holes in the ceiling to the fixtures and enclose them in the flexible tubes. For mounting the fixture, nail a piece of board between the joists right over the ceiling plaster. This will hold the screws used to mount the fixture, permitting them to go clear through the plaster into the board.

Fig. 57. Showing installation of drop-light snap switch.

In joining on the short wires, the ends for about three niches should be bared to the copper and scraped bright. The insulation on the main wires is also cut away and the copper scraped bright for a couple of inches. The short ends

are then tightly twisted around the bared spot in an open spiral, as shown in Fig. 58. It is best to have all joints open and to solder them at one period to save time and labor. After soldering the joints must be taped to properly insulate the wires. This is preferably done while the joint is still hot, as the tape will adhere better on a hot joint.

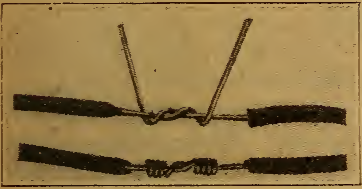


Fig. 58. Method of making a good splice joint.

Outdoor Wiring.

For distances greater than 100 feet, or where it is necessary to avoid trees or other buildings, poles may be used to carry the wires on brackets and insulators, as shown in Fig. 59. In order to avoid unnecessary strains, it should be remembered that a copper wire stretched very tight in summer will tighten much more in cold weather; therefore, the degree of tension on the wire must be gauged according to the temperature the day it is put up.

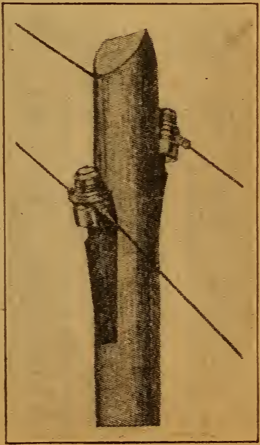


Fig. 59. Method of supporting wires from poles.

For entering the wall, two holes are bored for tubes slanting upwards, as shown in Fig. 60, about one foot apart. Then an oak bracket is nailed near each hole and a glass in-

sulator screwed on each bracket; start at the high point and attach the wires to the insulators. Ends long enough to make the inside connection are then thrust through the holes, the porcelain tubes being put in from the inside of the building, as this is the most convenient. The wires are then made fast to the insulators outside, taking care to avoid having the wires touch anything except the insulators. Finally, the ends are attached to the switchboards and the installation is complete.

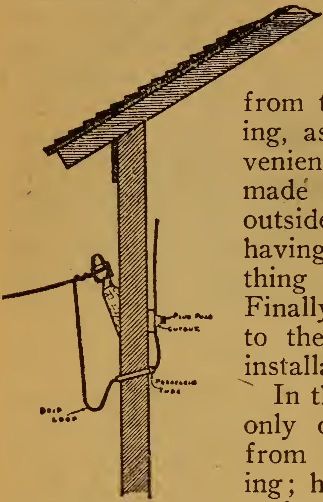


Fig. 60. Showing proper method of running wires into buildings through walls.

In the above description the only outdoor wiring is that from the barn to the dwelling; however, various combinations may be obtained, and the diagrams shown in Figs. 61 and 62 are examples of the various combinations which may be worked out.

Type and Size of Wire to Use.

For outside work, use weather-proof wire; for inside work use rubber-covered wire. In order to enable the reader to choose the proper size wire, the accompanying chart is quoted by the General Electric Company in their catalogues.

The proper size of wire is dependent upon the voltage of the circuit. Two different voltages are used, 32 and 110 volts. In selecting wire one should bear in mind that larger-sized wire is required for a 32-volt circuit than for a 110-volt circuit carrying the same amount of light or

power. This is due to the fact that the amount of current or amperage required on a 32-volt circuit is nearly four times as great as on the 110-volt circuit.

In selecting wires it is important to choose wire large enough to present an appreciable drop in voltage, for this will affect the brilliancy of the lights and the operation of the motors. By referring to either of the charts shown you will be able to determine very accu-

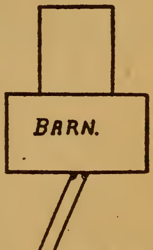
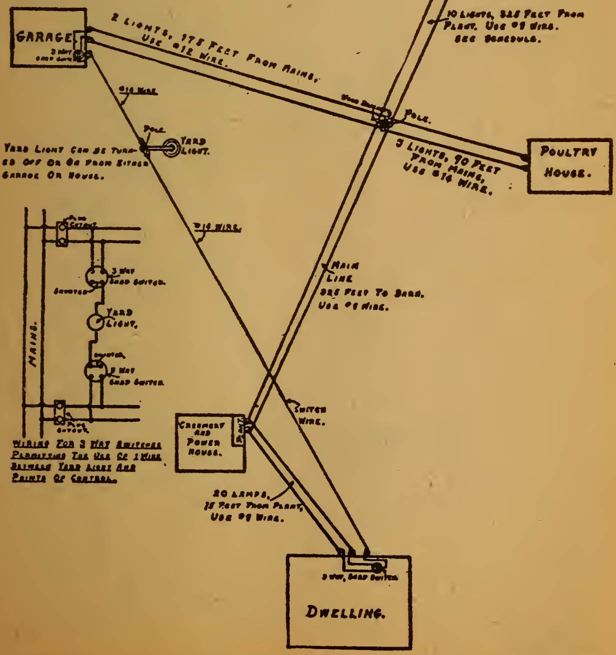



Fig. 61. Wiring for outbuildings and yard light controlled from 3-point switch.

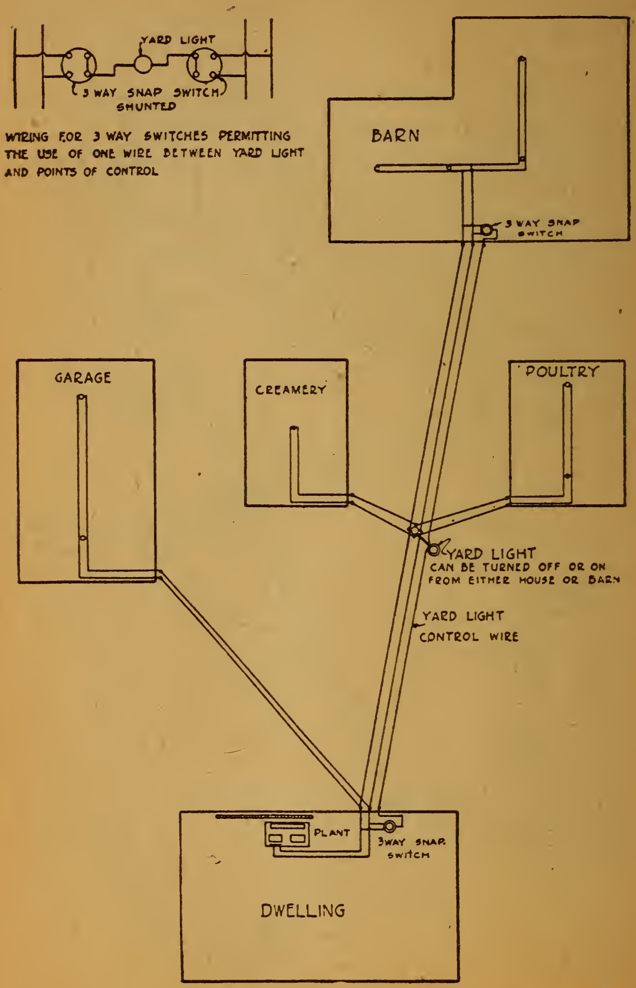


Fig. 62. Another suggestion for wiring outbuildings and yard light.

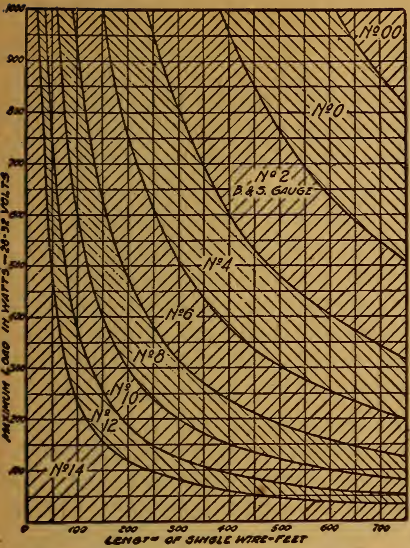


Chart for Determining Size of Wire 32-Volt Circuits.

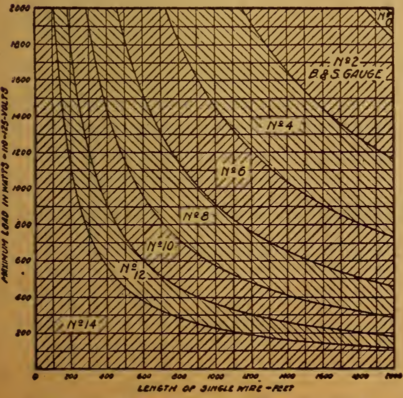


Chart for Determining Size of Wire 110-Volt Circuits.

rately what size wire you should use for either the 32 or 110-volt systems. Bearing in mind to get the wire plenty large, for you will get less voltage drop as you increase the size of the wire used. All you need know is the distance and the maximum amount of power in watts that is to be carried.

For example, assuming the system is of the 32-volt type, you estimate that you will have a load of 280 watts that is to be carried to a socket 110 feet from the source of current, the total distance the electricity has

to travel is 220 feet, since there must always be two wires leading to every fixture or power socket. As shown in Chart 1, the two lines indicating 280 watts and 220 feet cross in the space marked No. 8, indicating that No. 8 wire is required. When any lines indicating watts and distances cross in the light space No. 8, No. 8 wire is required. Similarly for a load of 400 watts to be transmitted 150 feet from the source, or a total of 300 feet, we find No. 6 wire is required. Likewise, when making other calculations, follow the wattage line and distance line to their intersection point on the charts, the size wire required is shown in the intersecting space. In this matter you can determine the size wire for any wattage and distance which you will need. Chart No. 2 gives the same data for 110-volt systems and is read in a similar manner. These charts are given in table form in the Appendix.

Electrical Consumption Data.

Before proceeding to determine the size wire required, it may be well to know the consumption in watts of some of the more common uses for electricity. Having tabulated your various devices, the following table will help you to decide the load in watts which the wires will have to carry:

Current Consumption of Various Appliances.

STANDARD SIZE LAMPS

32 Volt	110 Volt
5 Watts— 3 Candle Power	10 Watts— 6 Candle Power
10 Watts— 7 Candle Power	15 Watts— 10 Candle Power
20 Watts— 15 Candle Power	25 Watts— 18 Candle Power
40 Watts— 32 Candle Power	40 Watts— 30 Candle Power
50 Watts— 55 candle Power	50 Watts— 37 Candle Power
75 Watts— 85 Candle Power	75 Watts— 69 Candle Power
100 Watts—125 Candle Power	100 Watts—100 Candle Power

HEATING DEVICES.

No. 1	Western Electric Iron	525 Watts
No. 111	Western Electric Curling Iron	90 Watts
No. 5205	Western Electric 1 Pint Water Heater	300 Watts
No. 5215	Western Electric 1 quart Water Heater	500 Watts
No. 5828	Western Electric Toaster	440 Watts
No. 2316	Western Electric Percolator	420 Watts
No. 3210	Western Electric Disc Stove	450 Watts
No. 3231	Western Electric Disc Stove	600 Watts

MOTORS.

⅛ H. P.—Output	95 Watts	Input 150 Watts
⅙ H. P.—Output	125 Watts	Input 175 Watts
¼ H. P.—Output	185 Watts	Input 350 Watts
½ H. P.—Output	375 Watts	Input 700 Watts
¾ H. P.—Output	560 Watts	Input 1050 Watts
1 H. P.—Output	746 Watts	Input 1250 Watts
1½ H. P.—Output	1120 Watts	Input 1870 Watts
2 H. P.—Output	1492 Watts	Input 2500 Watts

ACCESSORIES

Churns	175 to 700 Watts
Dish Washer	100 Watts
Incubator	25 Watts
Sewing Machine or Motors	20 Watts
Vacuum Cleaner	120 Watts
Pumps	150 to 700 Watts
Washing Machine	230 Watts
Fans	20 to 60 Watts

Current Used for Farm Lighting.

The following table gives approximately the total number of watts in Tungsten lamps required to illuminate adequately each of the rooms in a dwelling, barn and outbuildings.

The illumination will depend somewhat upon the decorating on the walls. If these are dark-colored, more light will be required than is indicated in the table. Also, if sockets are poorly located, so as not to light the whole room to best advantage, more powerful lamps will be required. When these two conditions—namely, dark decorations and poor location—exist together, often twice as much light will be needed as is specified in the table:

Room	Small	Average	Large
Living Room	100 Watts	150 Watts	250 Watts
Dining Room	75 Watts	100 Watts	150 Watts
Kitchen	50 Watts	75 Watts	125 Watts
Pantry	25 Watts	25 Watts	50 Watts
Reception Hall	10 Watts	25 Watts	50 Watts
Bath Room	25 Watts	50 Watts	75 Watts
Bedroom	50 Watts	75 Watts	100 Watts
Attic or Basement	25 Watts	50 Watts	75 Watts
Porches	10 Watts	25 Watts	50 Watts
Nursery	50 Watts	75 Watts	100 Watts
Sewing Room	50 Watts	75 Watts	100 Watts

The figures given above signify the sum total of Tungsten lamp wattage required for each room. Thus, for an average-sized living room, 150 watts of lamp capacity are specified. This total wattage may be divided up between the central fixture and one or more table lamps

For small, one-car garages, 40 to 50 watts should be provided. Closets, one 10-watt lamp each; portable or reading lamps, one 25-watt or 50-watt lamp in each socket. For the barn, use 20-watt lamps when needed; also in the stable, driveway and hayloft. For dairy barn, 20-watt lamps will also suffice.

For power purposes, the various size motors required are listed below:

Machine	Horsepower	Machine	Horsepower
Washing Machine	⅛—¼	Forge Blower	¼
Cream Separator	⅛—¼	Bone Cutter	¼—½
Fan Mill	¼	Corn Sheller	½— 1
Churn	¼	Pump	¼— 1
Grindstone	¼	Drill Press	¼

The above covers in a general way the problem of wiring and current consumption for lighting and utility purposes. For conditions not covered in the text, it is advisable to consult the manufacturer of your equipment, who will be more than pleased to solve your power and lighting problems for you and forward the necessary wiring diagrams.

ELECTRIC GENERATORS AND MOTORS.

Operation, Field Windings, Armature and Commutator.—Care of Generator.

ELECTRIC GENERATORS and motors are not new, as they have been made for a number of years for high-power purposes. Ordinarily, these must be so designed as to run continuously without heating up and deliver or generate power efficiently. The general design has always shown a tendency toward simplicity and accuracy of working, so that one does not require anything but a scanty knowledge of the inner workings. Yet it is interesting to have a sufficiently clear idea of the operation of such units, and this will materially assist in providing the necessary care to keep it in good condition. To many, even those with keen mechanical curiosity, the very mention of the word electricity is almost enough to make them feel that the subject is beyond them. However, these supposed difficulties are largely imaginary, as the following text will prove.

The generator, which is generally driven by an internal combustion engine, or other source of power, generates the electricity which can be used direct, or stored up in the storage battery for future use. In other words, the generator is a machine for changing mechanical power or energy into electrical power or energy, and constitutes a very important part of any utility power plant. The advantages of electrical power are many; for example,, machines and appliances need not be grouped around the source of power,

but can be installed wherever wires can be run, such as motors for driving fans, sewing machines, churns, cream separators, etc.

The electrical system comprises two or three main elements and a number of subsidiary. There is, first, the electric generator, which produces the electrical energy consumed by lamps and power appliances; then there is the storage battery, in which the electrical energy generated is stored until it is needed; and finally, there is the electric motor, which furnishes the mechanical power to drive various machines. An electric motor and an electric generator are substantially one and the same machine—if we limit ourselves to continuous current machinery. Any electric generator will serve as an electric motor, and vice versa. If the machine is driven from some source of mechanical power it generates electric current, and if electric current from an outside source is sent through it, it develops mechanical power.

Principles of Generator.

The generator operates on substantially the same principle as a magneto, the only essential difference between the two being that the field frame of the former is an electro-magnet, while that of the latter is a permanent magnet.

All generators, like a magneto, generate an alternating current. This may either be used as such, or it may be transformed or commutated, before it leaves the machine, into a direct or continuous current, this being accomplished by a device known as the commutator. The essential parts of a generator are as follows:

1. A field frame, producing a magnetic field of force.
2. An armature, carrying conductors in which

an electromotive force is induced as the armature is revolved in the magnetic field.

3. A commutator, which "commutates" the induced current, changing it from an alternating into a direct current.

4. A brush rigging and brushes, for collecting the current from the revolving commutator. Fig. 63 illustrates the conventional type of shunt wound generator, which is practically the simplest form used. *"A"* is the armature, which revolves in the fields; *"F,"* the shaft of the armature, be-

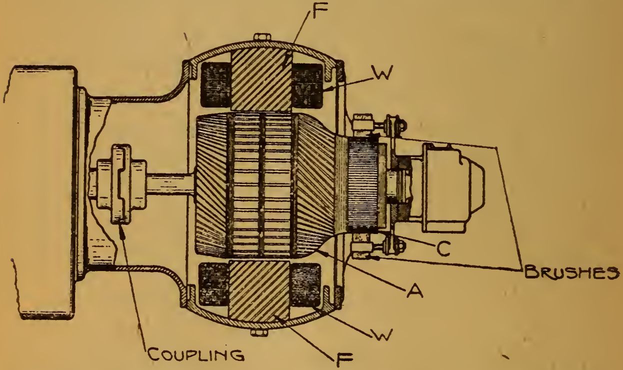


Fig. 63. Sectional view of generator, showing armature and field windings.

ing driven by means of the coupling by same source of power. The field windings, *"W,"* energize the fields and consist of many turns of fine wire. The armature windings, as they pass through the lines of force produced by the fields, generate electrical power, which is collected from the commutator, *"C,"* and delivered to battery or service lines as required.

Field Connections.

There are several different methods of connecting the field coils to the armature and the

characteristics of the dynamo vary greatly with these. If the fields are wound with a relatively small number of turns of heavy wire and the whole of the current derived from the armature is sent through this winding before it is sent to the consuming devices, such a machine is termed a series generator or dynamo. This type is seldom used, as it has a number of disadvantages, principally, though, for the reason that its voltage varies greatly with the load, while a constant voltage is very desirable.

The second method is known as the shunt wound. In this the field is connected across the armature. In this case the current flowing through the field is always proportional to the electro-motive force of the armature and is almost wholly independent of the load carried by the dynamo.

Where an absolutely constant voltage is required, the dynamo may be provided with both a shunt and a series field winding, or what is commonly termed a compound winding. In a straight shunt wound machine the voltage tends to drop slightly as the load on the dynamo increases, but through the addition of a few series field turns, the strength is increased as the load rises, and compensates for the drop in voltage.

All of the preceding considerations apply to conditions of constant speed, under which condition nearly all stationary generators are operated.

Operation of Series Wound Generator.

The operation of the series generator may be explained as follows: In Fig. 64, assuming that there is some residual magnetism in the fields, due to their having previously been magnetized,

there will be a low electrical pressure induced in the armature winding when the armature is revolved in this weak magnetic field. This induced electrical pressure will not produce a current unless the terminals of the machine be connected directly together or by means of an external circuit. The current due to this low induced electrical pressure will flow through the field winding and increase the strength of the magnetic field, which in turn will increase the

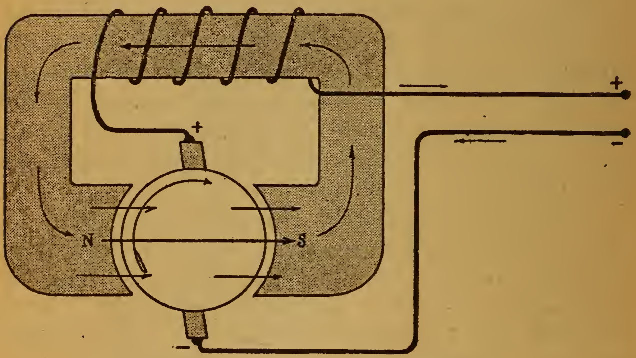


Fig. 64. A series field winding.

induced electrical pressure. This operation would continue indefinitely and the induced pressure and current would both become dangerously high unless some means were provided for controlling them. As the current in the field windings increases, the number of magnetic lines in the field increase, but after a certain field strength has been reached, the magnetic lines cease to increase, due to a given increase in current, as rapidly as they did at first; and finally there is very little increase in these lines, due to an increase in the field current, and the iron forming the magnetic circuit is said to be saturated.

Operation of Shunt Wound Generator.

In Fig. 65, the current in the field winding at any time is equal to the pressure between the brushes divided by the resistance of the winding and is independent of the current the generator may be supplying to circuit connected to its terminals, unless the current supplied changes the pressure between the brushes. The shunt generator will have a low pressure induced in its armature, due to the residual magnetism in the fields.

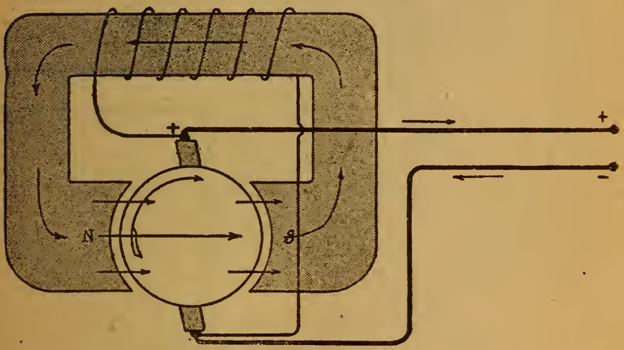


Fig. 65. A shunt field winding.

This produces a current in the field windings, which in turn increases the strength of the magnetic field. This in turn increases the induced pressure, which increases the field current, etc. This operation continues until the magnetic condition of the iron is such that both the electrical pressure and the field current become steady. In the series generator, the terminals of the machine had to be connected together in some way in order that the electrical pressure induced in the armature increases, while in the shunt generator it is not necessary to have the terminals connected together in order that the electrical pres-

sure induced in the armature increases. In fact, it is best to have the terminals entirely disconnected from all circuits.

Operation of the Compound Wound Generator.

In Fig. 66, when the magnetizing action of the series and shunt fields are in the same direction, it is called a cumulative compound generator. If the magnetizing action of the series and shunt

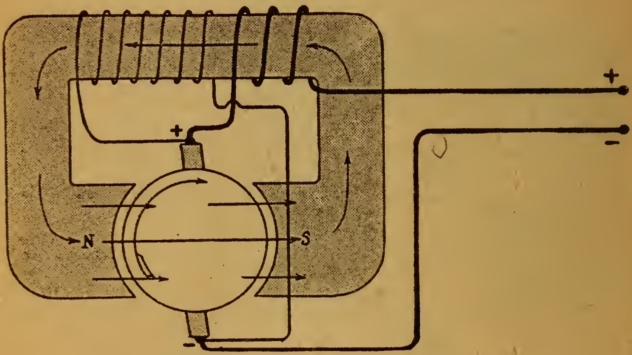


Fig. 66. A compound field winding.

fields are in opposite directions, it is called a differential compound generator. These field windings usually control the current supplied to the battery and service lines.

Brushes and Commutator.

The component parts of a generator are illustrated in Fig. 67, and it will be noted that four field windings are provided, while the commutator is built on the armature. Fig. 68 shows the arrangement of the brushes in relation to the fields, also the conventional rocker arm and brush rigging which supports and holds the brushes.

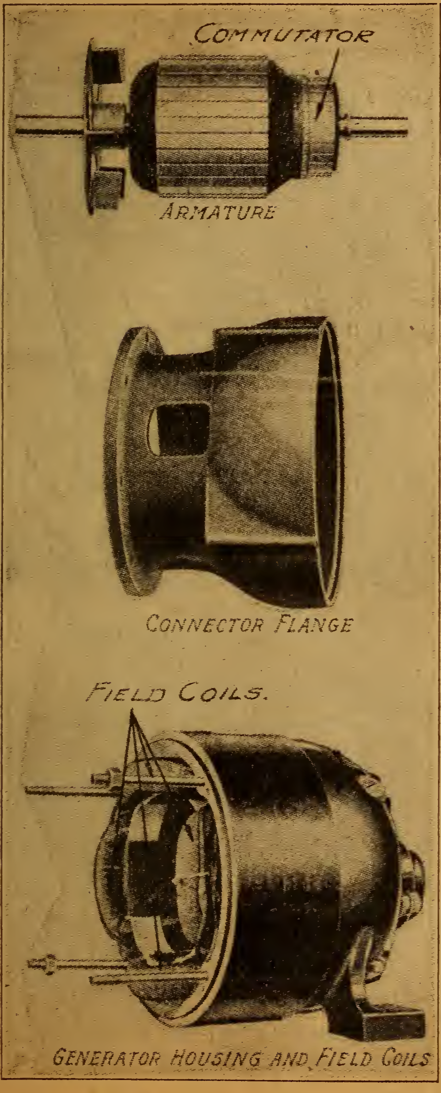


Fig. 67. Main parts of a generator.

These brushes are approximately on a line with the fields, or perhaps have a slight lead, while for a motor they should be located a little behind the center of the fields. The brushes which take off the current are generally made of carbon or graphite and are pressed against the commutator by a spring. Since the spring presses directly against the current-carrying brush, its support or anchorage must be insulated from the generator frame.

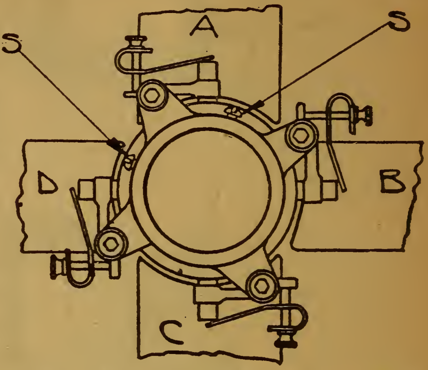


Fig. 68. Arrangement of brushes on commutator.

Cooling of Generator.

Owing to the heavy loads carried by the generator, some provision must be made for cooling, so as to prevent undue heating. This is usually accomplished by ventilation. The engine flywheel is provided with fan blades (described in previous chapter), which draws the air used to cool the engine or cooling medium through the generator. This provides a reasonable amount of ventilation to keep generator at proper temperature and thus prevents alternate heating and cooling, which might loosen up the commutator bars and brushes. Overheating will eventually result in aggravated brush troubles, excessive sparking and the destruction of the commutator.

Care of Generator.

When first starting a generator after it has been set up, the bearings and oil wells should be carefully washed by flushing with kerosene or any other light oil, as it frequently happens that dirt and foreign matter get into the bearings in transportation. See that oil wells are properly filled and all points properly lubricated in accordance with the maker's instructions. A good grade of fairly light generator oil should be used, and when starting the plant, feel off the bearings occasionally to make sure there is no heating. The oil should occasionally be drained from the oil wells and replenished with fresh oil. While doing this, the wells can be flushed to remove any particles of metal which may have worn from the bearings. This is particularly true if bronze bearings are used. The majority of modern generators are equipped with ball bearings, and these require very little attention, except a few drops of oil at intervals as specified by the maker. One point of considerable importance is to avoid over-lubrication. This is due to the fact that oil accumulations are an enemy of good insulation. Oil always collects dust. The dust inside of a generator is very likely to consist of particles of conducting material worn off the commutator and brushes. The accumulation of this dust and oil is very likely to short-circuit the machine.

Care of Commutator and Brushes.

In order that the generator may operate at maximum efficiency the commutator end of the generator armature must be clean and the brushes must sit firmly upon the commutator. These brushes will gradually wear away and the carbon

dust and dirt will cause the commutator to become dirty. This is particularly true when the commutator becomes oily or greasy.

The commutator should never be oiled and it should be kept perfectly clean at all times. About once a month the end cover over the brushes should be removed, and the commutator cleaned with a piece of cloth free from lint, as shown in Fig. 69. Cheese cloth moistened with kerosene, held against the commutator while the machine is running, will remove grit and dust.

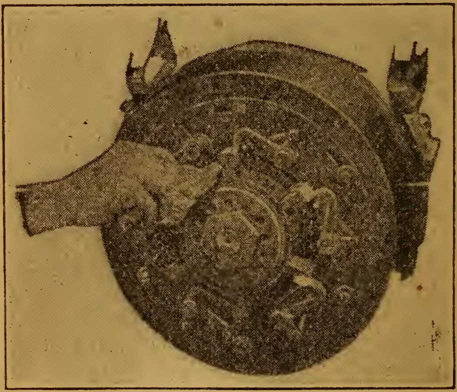


Fig. 69. Method of cleaning commutator.

The brushes should always press firmly against the commutator, as it is very essential that good contact be maintained. Poor contact, due to weak springs or brush arms not moving freely, or badly fitting brushes, will cause decreased efficiency. Occasionally lift the brushes from the commutator in order to see that they move freely and that the spring tension is good. In some designs the movement of the brush arm is limited by a stop to prevent the brush from wearing to

such an extent that the brush arm cannot touch the commutator. When the brush arm strikes the stop pin, it becomes necessary to insert new brushes, which is very easily done.

Sanding-in Brushes.

When new brushes are fitted they must be bedded to the commutator. In some cases the brushes are arranged to stand radially to the

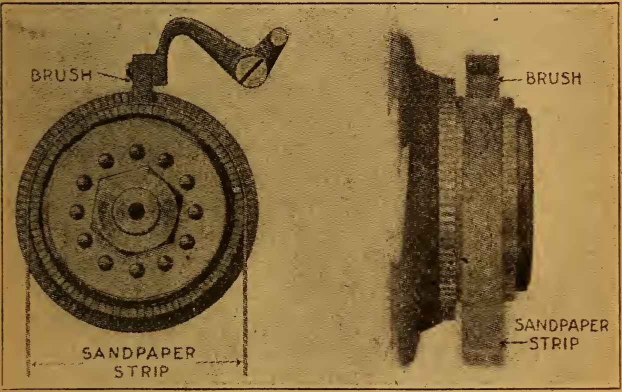


Fig. 70. Method of sanding-in new brushes.

commutator, but generally they stand at a slight angle, so that the friction between the brush and commutator tends to increase the pressure between them. The brush is first ground or filed down on its bearing surface to the approximate angle of contact. Then it is placed in position in the brush holder, a sheet of fine sandpaper is placed on the commutator, as shown in Fig. 70, with the back of the paper side toward the latter and the "business" side toward the brush, and while pressing down on the brush, the paper is drawn back and forth over the surface of the

commutator. In this way the brush is soon worn down to a cylindrical surface conforming to the wearing surface of the commutator.

Controls.

The controls usually provided with auxiliary power plants are generally incorporated on a switchboard built integral with the unit. These consist of various elements, depending upon the design of the plant; however, they may be provided with all switches, main fuses, resistance and current control units, etc. From this board all connections are made to outside lines, so that the switchboard is in effect a centralized control. Details of the board, as well as the various units which are mounted upon it, vary with each design, and as each maker covers the switchboard and its construction in his instruction books, space will not be devoted here to describing all the different types. A trouble chart is, however, appended, so as to enable the reader to trace trouble in any plant by consulting his instruction book and the trouble chart. In nine cases out of ten the best advice that can be given is to leave the generator alone, as the trouble is usually found in other units. The principal troubles are blown fuses, open or short-circuited lines and grounds.

Generator Troubles.

1. *Sparking at Brushes.*
   - (a) Dirty commutator, clean with rag or fine sandpaper.
   - (b) Brushes are worn down short or they stick in holder so that they don't make good contact with surface of commutator.
   - (c) Brushes not set properly.
   - (d) Short circuit in armature.
   - (e) Open circuit in armature. This will cause a very vivid or fat spark.

2. *Generator Won't Develop Power.*
   - (a) Open field or poor connection in field circuit.
   - (b) Poor contact between brushes and commutator.
   - (c) Brushes not set properly.
   - (d) Engine not furnishing sufficient power to produce voltage.
   - (e) Opening in armature circuit or leads from brushes to switch board.

3. *Generator Will Not Crank or Turn Engine.*
   - (a) Open field causing excessive flow from battery.
   - (b) Tight bearings or binding of moving parts.
   - (c) Battery is low.
   - (d) Open circuit in armature leads.
   - (e) Short crcuit in armature.

STORAGE BATTERIES.

Construction, Care and Mounting.

THE majority of batteries supplied with auxiliary power plant are of the lead-acid type, while some few makers recommend the Edison battery. These batteries consist of three main parts—the positive and negative plates and the electrolyte which is a diluted sulphuric acid solution. There are other parts, such as the jars, separators, and connectors; however, they are of minor importance, since they are not parts upon which the entire service of the battery rests.

Since a negative plate is always placed at either end of a positive plate, there must always be an odd number of plates to each cell. This is an advantage, as there will be an action on each side of the positive plate. All positive plates are connected together by a lead strap or brass bar at the top, with a connecting strap protruding through the top of the cell. Similarly, all negative plates are connected together. The series of positive plates are placed between the series of negative plates so that there will be alternately a positive and a negative. However, there must be some provision to keep the plates from touching, and this is accomplished by what are called separators. These are either made of specially prepared wood and ribbed, or of hard rubber. Each set of plates with connectors is called a group, while the complete assembly of plates and separators is called a plate assembly, and these are housed in hard rubber or glass jars. In some types of batteries the jars are sealed, while in

others they are not sealed. Hard rubber supports or ribs are placed at the bottom of these jars upon which the plate assembly rests, and when the jar is sealed, the top is covered with a compound and sealed with a tar or asphalt material.

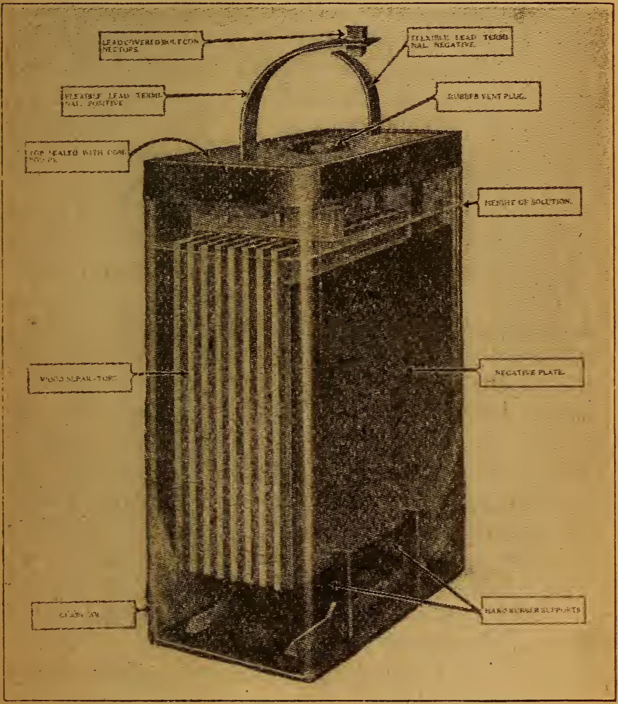


Fig. 71. Storage battery cell.

The connecting straps of each series of plates protrude through this covering. The entire assembly of plates, jar, cover and straps is called a cell, which is the unit of a storage battery. This is illustrated in Fig. 71. It is customary with

some makers to make the negative strap short and the positive strap long, so that they may easily be distinguished. Each cell is filled with electrolyte and provided with a vent plug as illustrated.

Capacity of Batteries.

The capacity of a storage battery is the amount of electrical energy which can be obtained from it. The unit in which capacity is measured is the ampere-hour. Theoretically, a battery has a capacity of 100 ampere-hours, if it furnishes 10 amperes for ten hours, and if it is unable, at the end of that time, to furnish any more current. If we draw only five amperes from this battery it should be able to furnish current for 20 hours. Thus, theoretically, the capacity of the battery should be the same, no matter what current is taken from it. That is, the current in amperes, multiplied by the number of hours that the battery furnished this current should be constant.

In practice, however, a battery cannot be discharged to a lower voltage than 1.7 per cell on account of difficulties encountered through the chemical action of the electrolyte on the plates. The capacity of a storage battery is therefore measured by the number of ampere-hours it can furnish before its voltage drops below 1.7 per cell. This, of course, assumes that the discharge is a continuous one.

The average electromotive force during charge is 2.3 volts and the average during this charge is 2 volts. The electromotive force increases continuously during the charge and decreases during discharge. It attains a maximum value during charge of about 2.55 volts, but ten minutes after charging ceases it has dropped to about 2.1 volts. It is at this voltage that discharge begins, and the latter should never be continued

after the voltage has dropped to the lowest point specified by the maker (varies from 1.2 to 1.7 volts per cell), if the cell is not to be injured.

Storage batteries of the type used in connection with lighting and power plants are composed of a number of cells, depending upon the voltage of the system. For 30-volt systems, 15 to 16 cells; for 32-volt systems, 16 to 17 cells, and for 110-volt systems, 55 to 56 cells. This number of cells is necessary, since the voltage of one cell cannot be greater than two volts. Some makers rate the capacity of battery upon the basis of the lowest discharge voltage; thus, if this is taken at 1.2, for 30-volt systems 25 cells will be required. The various cells are connected together by the connecting straps, the positive being connected to the negative. Counter E. M. F. (electromotive) cells are sometimes furnished, depending upon the type of battery and the general design of the power plant. The object of this end cell or counter-cell regulation, is to reduce the voltage to the lights while the battery is being charged. If there is a great deal of lighting being done while the battery is being charged, end cell regulation is desirable, as it permits uniform voltage at lamps even though the generator voltage while charging is considerably higher.

Plate Construction.

The plates, regardless of whether they are positive or negative, have the same framework or grid. They are made of lead containing antimony in proper proportion to give the required strength. The grid is made up of a series of rectangular cells formed by vertical and horizontal ribs. These cells are filled with what is known as the active material. This material is in the form of a paste, and that of the negative

differs from the positive. Pure lead of a spongy character, combined with other chemical substances, which give it the required body and adhesive properties, is filled into the cells of the negative plate. This composition is of a gray color. The positive plates require a somewhat different mixture of lead oxides, such as red lead, etc., combined with proper chemicals to provide the body and adhesive qualities. Thus it is always possible to distinguish between negative and positive plates by color. The negative plate being gray, while the positive has a reddish-brown color. Special processes are employed to put the active material into the grid cells, and a finished plate has a comparatively hard surface, with the active material flush with the ribs which form the sections of the grid. Fig. 72 illustrates a group of plates with cover and connecting straps assembled. This represents the complete group which is placed in the glass or hard rubber jar. Fig. 73 shows a 16-cell assembly of Philadelphia diamond grid battery for a 32-volt system.

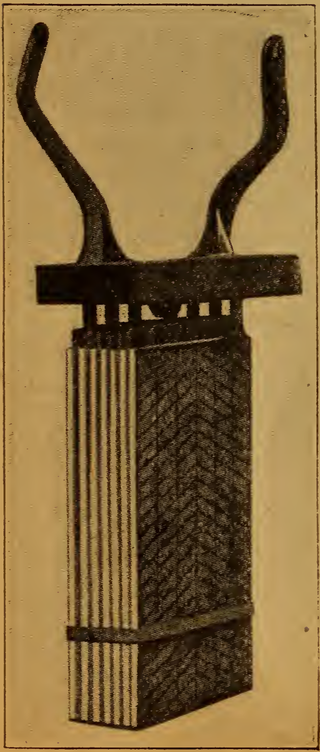


Fig. 72. Plate assembly of a storage battery.

Each of the plates are separated by wood or hard rubber separators. This separator is illustrated in Fig. 74, which also shows positive and negative plate and grid. The office of this separator is to prevent a positive and negative plate from coming in contact with each other. It is a specially shaped piece of a special kind of wood, chemically treated through several processes. They are thin, and while their strength could be

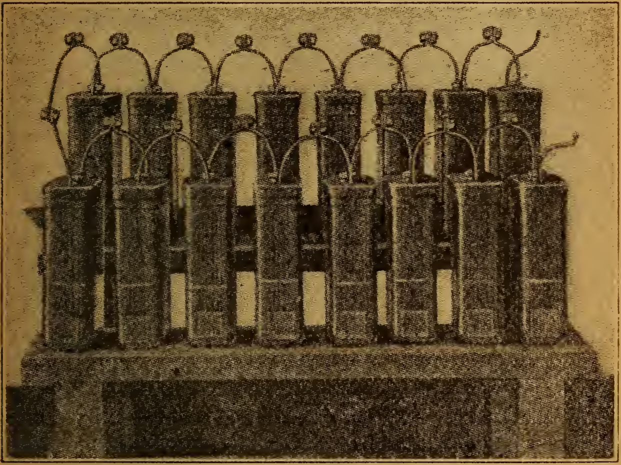


Fig. 73. 16-Cell assembly, giving 32 volts, mounted on wood shelves.

increased with greater thickness, it would retard the rapid diffusion of electrolyte through the pores of the separator. As this diffusion is reduced that capacity of the battery diffuses.

Electrolyte.

Electrolyte is a definite mixture of chemically pure sulphuric acid and water, the latter having been distilled to secure purity. Certain ingre-

dients in what is known as commercially pure acid and in almost any undistilled water would affect batteries as typhoid affects the human being. For example, the ammonium compounds in ordinary acids would decompose the antimony-lead grids, which are impervious to true electro-

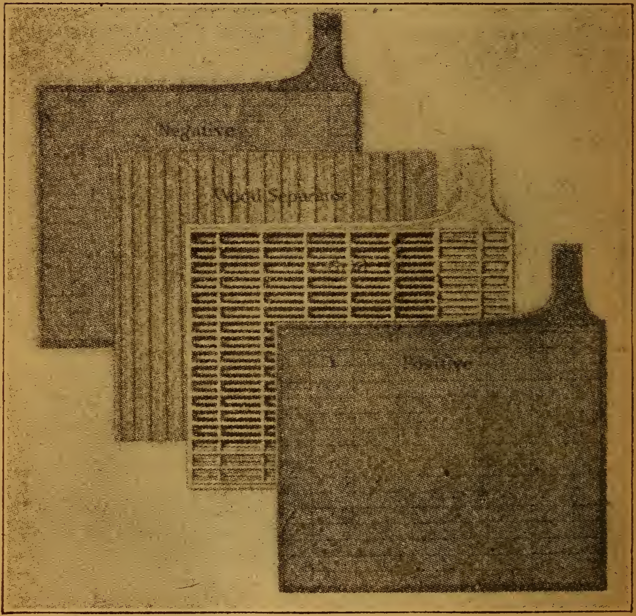


Fig. 74. Positive and negative plate, grid and wood separator.

lyte. Instruction for mixing and adding solution or distilled water to the cells are given below under the caption of Care of the Battery.

Action of Battery.

Opinions differ as to action that takes place within the cells of a battery when storing electrical energy and when giving it out. However,

it is fairly well understood that the action is an electro-chemical one. There is no action whatever until a current is passed through the battery. Primarily this action is simple. It is simply a device which breathes in acid and discharges electricity, or, conversely, breathes in electricity and discharges acid. The acid being the solution surrounding the plates. The plates, therefore, may be termed the lungs of the battery. When a battery is charged the plates are full of electricity and the acid surrounds them; while when it is discharged the electricity is expelled from the plates or lungs, while acid enters them. This is the fundamental process which takes place. Any departure from normal conditions in the battery shortens its life, just as any departure from normal conditions affects the health and existence of a human being.

Taking the battery in a completely discharged state, both positive and negative plates will be found covered with lead sulphate. As the electric current begins to pass through the cell, the lead sulphate on the positive plate is changed to lead peroxide, and that on the negative plate is split up so that the sulphate combines with the hydrogen in the water to make sulphuric acid, leaving a pure lead of a spongy character on the plate. The cell is completely charged when all of the sulphate is off the plates and has combined with other elements to make sulphuric acid. As this acid is heavier than water, this causes the gravity to rise as charging continues; this explains why the hydrometer is used to indicate the condition of a battery cell.

When the battery is being discharged, or, in other words, is giving up its current, the chemical action is in the opposite direction, the lead or the negative plate combines with the sulphate

to form lead-sulphate again and the peroxide at the positive combines with the hydrogen and sulphuric acid to form sulphate of lead and water.

It should be remembered that the plates act as the lungs of the battery to breathe in acid before it can discharge electricity, and therefore only that portion of the plates which are covered with acid bear any share of the burden of producing current. The plates will crystallize above the points where they are submerged in liquid; this crystallization is commonly called sulphation. Thus it can readily be understood that a battery which has only half of the plate area covered by solution or electrolyte can only possibly have half the capacity. From the above it can readily be understood that the storage battery is not a source of electrical energy, but only a receptacle for temporary storing electrical energy.

Mounting of Battery.

To obtain the greatest economy, the battery should be located near the central part of the lighting load; that is, taking an average form for example, there are few lights in the barn and other outbuildings, but the largest number of lights are in the house; therefore it would appear advisable to place the battery in the basement, provided it is not too damp. While it is desirable in many ways to have the battery near the plant proper, still this is not absolutely necessary, but it will require larger-sized wires in making connections to the switchboard if the battery is located at any appreciable distance from the plant. For the most efficient working the battery should be kept warm, which is another advantage of locating in the basement. Lead-acid type batteries must also be kept out of the direct sunlight. It is entirely feasible to locate the battery in an

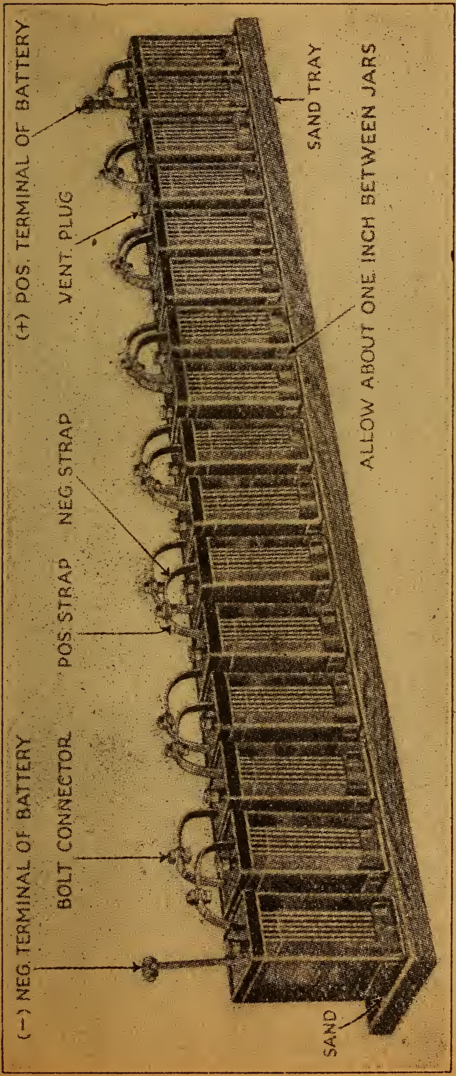


Fig. 75. Battery of 16 cells mounted in a sand tray.

outbuilding, but in doing so it is advisable to cover and enclose the battery in an insulated box, for the battery, when in action, generates heat, which should be conserved, especially in cold weather.

Fig. 73 illustrates a 16-cell battery mounted on a substantial shelf made of 4x4 timbers and two-inch boards. There are three general meth-

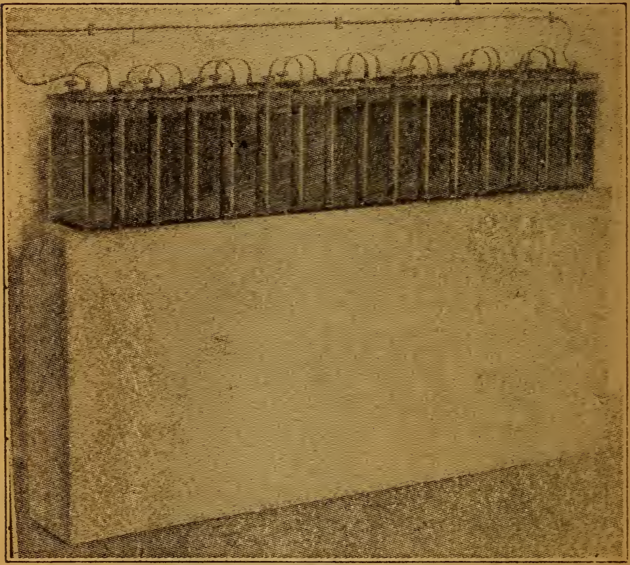


Fig. 76. Battery mounted on concrete shelf.

ods of supporting batteries; for example, in Fig. 73, batteries mounted on shelves in two rows; Fig. 75, batteries mounted in a row on a sand tray, and Fig. 76, mounted in a row on a concrete foundation. The methods shown in Figs. 73 and 75 are preferable, as the initial expense is low and the batteries may be moved to different localities when this is desirable. In each

case about one-inch space should be allowed between cells.

In making battery shelves it is advisable to use lumber one and one-half inch to two inches thick by ten inches wide, and so installed that they may be fastened to the wall or braced in some way so as to afford a solid support. If located in the basement they may be supported from the floor or joists, as preferred.

Connecting Batteries.

In mounting batteries, the cells should be so arranged that the positive terminal or strap marked (+) on each cell will be connected to the negative terminal or strap marked (—) on the next cell in the series. See that all connections are clean and dip the bolt connector studs in vaseline before bolting the lugs together. When counter E. M. F. cells are used, these are connected as shown in Fig. 77.

To Determine Size of Battery Necessary.

In the previous chapter, instructions were given as to location of lamps, etc., and after this has been decided upon, figure the number of hours per week each lamp will be burning during the winter months. Take, as an example, an eight-room house, having a kitchen, dining-room, living-room, parlor, bath and four bedrooms. We will assume the kitchen will require a 20-watt lamp, burning three hours per day or 21 hours per week; this will make 21 times 20, equals 420 watt hours per week. In a similar manner, figure the watt hours per week for each lamp and then obtain the total watt hours required per week.

By computing the number of lights you will burn and the power you will want to use, it is

a simple matter to determine the size of batteries required from any maker's catalogue. Take into consideration that it is always better to provide slightly larger capacity than you think you will need, for you will find the extra capacity of advantage in many ways or make new discoveries of reducing manual labor by power installations.

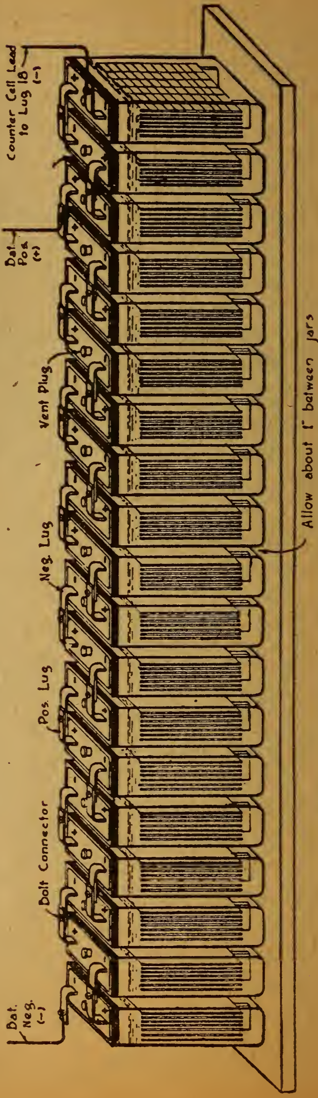


Fig. 77. Method of connecting counter E. M. F. cells.

The Edison Battery.

So far the lead-acid type battery has been considered, and while the Edison may also be placed under this heading, it may be desirable to describe the construction of this battery.

This battery differs from the lead-acid type, in that the active materials are replaced by nickel and iron salts and an alkaline solution. All the structural elements of the Edison cell — the

jar or can and the positive and negative plates—are made of sheet steel, nickel plated. The positive plate consists of tubes of perforated sheet steel, arranged vertically and fitted into a sheet steel grid. These tubes are filled with the active material, nickel-hydrate, interspersed with thin layers of nickel flakes to increase the conductivity. They are spirally wound and the edges are double-seamed. Nickel-plated steel rings are spaced along the tube on the outside to prevent it from expanding.

Iron oxide mixed with mercury oxide serves as the negative active material, and this is contained in rectangular pockets made from perforated nickel-plated steel ribbon. After the pockets have been filled with the active material, the plate is re-formed in a press which slightly corrugates the pockets and brings the sheet metal into more intimate contact with the active material, thus decreasing the internal resistance. The plates are assembled in positive and negative groups, respectively, by means of threaded steel rods passing through holes in one corner of the plates and steel spacing washers. To the middle of the rod is secured a terminal post. In order to keep positive and negative plates apart, separators in the form of hard rubber rods are inserted between them. The jar is made of thin sheet steel, corrugated for stiffness. The groups of plates stand on hard rubber bridges located in the bottom of the jar and are kept out of contact with the sides by hard rubber spacers. The cover is also of sheet steel, while in addition to marking the terminals the positive is provided with a red rubber bushing, while the negative terminal has a black rubber bushing to provide additional means of identification. This battery is illustrated in Fig. 78.

Care and Maintenance of Batteries.

Storage batteries will require a certain amount of attention to maintain them at their maximum efficiency. While this is pretty generally understood, this attention is usually very spasmodic, instead of at regular intervals as prescribed by manufacturers of these units. The result is, the battery suffers and deteriorates rapidly. Ninety per cent of battery troubles can be eliminated by proper maintenance. In describing the action of the battery in breathing in acid and current, it was mentioned that the plates must always remain covered with solution. This is one of the most important items in the care of the battery, as it requires periodic refilling to make up for evaporization. This refilling should be done with pure (distilled) water, at least every two weeks in warm weather and every four weeks in cold weather. Enough distilled water should be added to keep the plates submerged at least ¼-inch to ½-inch. The water used should not contain any salts or iron of any kind, and it is therefore necessary to distill it, or to use pure

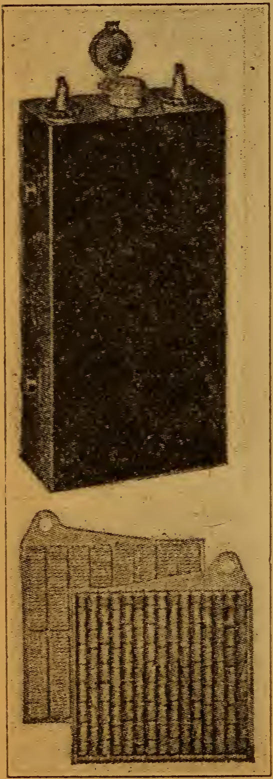


Fig. 78. Edison battery cell. Negative and positive plates.

rain water or melted artificial ice. The battery must be kept clean and dirt and water must be prevented from accumulating. Provide ample space around it and never lay tools or other metal parts on top of it, as these will short-circuit the battery. The terminals and connectors should be kept coated with vaseline or grease. Spilled solution should be wiped off with waste saturated with ammonia. Only clean vitrous vessels should be used for storing water and the battery should be filled regularly, although it may seem to function properly.

The best way to ascertain the condition of the battery is to test the specific gravity (density) of the acid solution in each cell with a hydrometer. This should be done at regular intervals. A convenient time is when adding water, but the reading should be taken before rather than after adding water. A reliable specific gravity test cannot be made after adding water and before it has mixed with the solution by several hours' charging. To make a reading with the hydrometer, hold it in a vertical position, compress the bulb and insert the nozzle as far as possible into a cell, lessening the pressure on the bulb until the hydrometer floats about ½ to ¾ of an inch above bottom. If the bulb does not suck up solution, raise the hydrometer slightly, as the nozzle may be closed by resting on the edge of a plate. When the hydrometer floats, raise the instrument and allow the bulb to expand, filling with air. The reading of hydrometer must be taken when there is no pressure on the bulb; that is, the bulb must be allowed to expand so that there will be no vacuum or pressure effect on the electrolyte. The reading is taken at the top of the solution. The intersections on the scale of the hydrometer at the top of the solution show the correct reading.

Hydrometers will often show incorrect readings on account of being in a state of static charge and being only partially wet; therefore, in order to make sure the readings are correct, first fill the syringe with solution so that the hydrometer will become wet over its entire surface, then proceed to make the test which will give a correct reading. Fig. 79 illustrates the type of hydrometer ordinarily used.

Fig. 79. Battery hydrometer.

When the battery is found to be half discharged, the lamps and other appliances should be used sparingly until the battery is again fully charged. A run-down battery requires a full charge at once. This condition is always the result of a lack of charge or waste of current, and is a reliable indication of trouble in the system which should be tabulated on a piece of paper, and if there is a marked difference in the readings of the various cells, especially if this seems to be increasing, that cell is not in good order.

There will be some evaporation with any type of battery. Only the water evaporates from the electrolyte, and no acid should be added to replace this loss, unless some of the solution has been spilled. Should one cell regularly require more water than others, thus lowering the gravity, a leaky cell is indicated. A slow leak will rob a cell of all of its electrolyte in time, and a leaky jar should be immediately replaced with a new one. If there is

no leak and the reading of a cell varies greatly, a partial short-circuit or other trouble is indicated within the cell.

Sediment will gradually accumulate at the bottom of the jars, and this must be removed before it touches the bottom of the plates. With glass jars this accumulation can readily be seen, which is one advantage of this type of jar.

If one or more cells run low in a battery for any

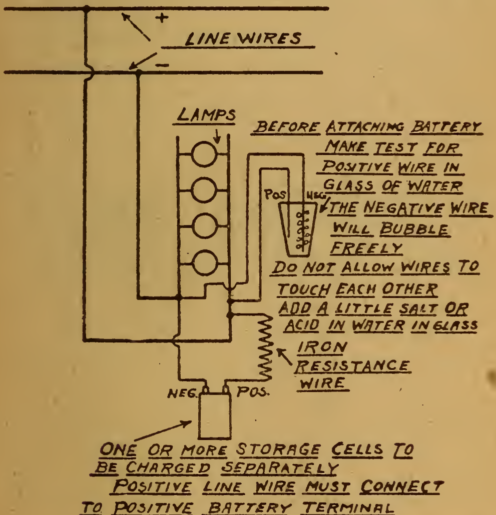


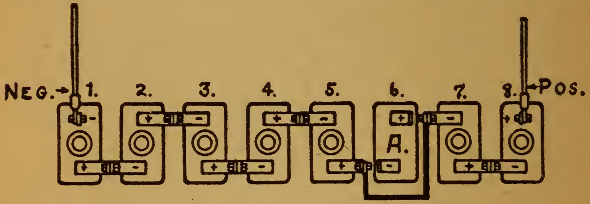
Fig. 80. Method of wiring to charge defriction cells.

reason, such as internal short-circuits, such cells should be charged independently for a prolonged period. This is accomplished by removing and connecting one or more cells, which may require charging, to the service lines as shown in Fig. 80.

Service may also be continued from the battery after removing any defective cells by bridging the space from which one or more cells may be removed with a piece of copper wire or a lead

strip, which is preferable. The lead strip or copper wire must be firmly bolted to the straps of the cells with lead bolts. This method of cutting out a cell is illustrated in Fig. 81, and is recommended when only one or two cells require special treatment. In this manner the defective cells are left out of the circuit on discharge. The cells must always be connected back into the circuit on charge, by removing the jumper wires.

In order to avoid freezing, the battery must always be kept fully charged. Freezing is directly dependent upon the specific gravity of the



To disconnect a cell or leave out of circuit on discharge, connect Jumper Wire as shown at "A."

Fig. 81. Method of cutting out cell on discharge.

solution in the cell. When the specific gravity is 1.190 the solution will freeze at zero, and for a temperature of 20 degrees below zero the specific gravity must be 1.215. In other words, specific gravity must be increased as temperature decreases. Therefore, if the maker's instructions to keep battery fully charged are heeded, it will not freeze.

This chapter, in a general way, covers the construction, care and maintenance of batteries. For a more detailed treatise on these subjects and the repair of batteries, the reader should consult "Storage Batteries: Their Care, Maintenance and Repair," published by the *American Automobile Digest.*

Appendix

Wiring Table, Giving Distance in Feet for Number of 20-Watt Lamps Burning at One Time.

Voltage	No. of Lamps	3	6	9	12	15	18	21	24	30	40	50
	Size of Wire	Maximum Distance at 3 Volts Drop or Less										
30 Volts	No. 14	290	145	97	72	58	....	....	....	....	....	....
	No. 12	430	215	143	108	86	71	61	54	....	....	....
	No. 10	730	365	243	182	146	121	104	91	73	54	....
	No. 8	1160	580	386	290	232	193	165	145	116	87	70
	No. 6	1840	920	613	460	368	306	263	230	184	138	110
	No. 4	....	....	974	730	584	487	417	365	292	219	175
	No. 2	....	....	....	....	932	776	665	582	466	349	280
32 Volts	No. 14	309	155	98	77	62	....	....	....	....	....	....
	No. 12	458	229	152	115	92	76	65	58	....	....	....
	No. 10	778	389	269	194	156	129	111	96	78	58	....
	No. 8	1236	618	412	309	247	206	176	155	124	93	75
	No. 6	1960	970	655	491	392	326	281	245	196	147	118
	No. 4	....	....	1004	778	622	520	445	389	311	233	187
	No. 2	....	....	....	....	995	827	710	620	497	372	298
110 Volts	No. 14	1065	533	356	264	213	....	....	....	....	....	....
	No. 12	1579	790	525	397	316	261	224	198	....	....	....
	No. 10	2680	1340	692	668	537	445	382	334	268	198	....
	No. 8	....	2130	1415	1065	851	710	606	532	426	319	257
	No. 6	....	3380	2250	1690	1240	1123	965	845	675	507	404
	No. 4	....	....	3575	2680	2145	1787	1530	1340	1072	805	642
	No. 2	....	....	....	....	3420	2850	2440	2140	1710	1280	1028

SPECIFICATIONS OF LIGHTING PLANTS.

NAME	Model	Capacity Number of 20-Watt Lamps	No. of Cylinders	No. of Cycles	Bore and Stroke	Cooling	Rated H. P.	Engine R. P. M.	Battery Amp. Hrs.	Battery Volts	Battery No. of Cells	Make of Battery	Make of Generator	Generator Drive	Governor Type
Aerothrust	....	15-25	2	2	2½x2¼	A	3	1800	60	30	15	......	......	Shaft	......
Alamo	....	......	....	....	......	..	...	....	......	....	....	......	......	....	......
Cushman	A	20-70	1	4	4x4	W	4	800	112	32	16	......	Imperial	Belt	Throttle
	B	25-75	1	4	4x4	W	4	800	168	32	16	......	Imperial	Belt	Throttle
	E	50-100	1	4	4x4	W	4	800	250	32	16	......	Imperial	Belt	Throttle
Delco	216	20-72	1	4	2½x5	A	1½	1000	80-160	32	16	Exide	Own	Direct	Voltage
	332	150	1	4	3¾x6	A	5	1200	80-160	32	16	Exide	Own	Direct	Voltage
	316	150	1	4	3¾x6	A	5	1200	80-160	110	56	Exide	Own	Direct	Voltage
Dyneto	5	10-42	1	4	......	W	1½	....	53	32	16	Willard	Own	Belt	Throttle
	7	16-54	1	4	......	W	1½	....	80	32	16	Willard	Own	Belt	Throttle
	9	23-65	1	4	......	W	1½	....	110	32	16	Willard	Own	Belt	Throttle
Everlite	....	50-100	1	4	2¾x4	W	3	1200	95-275	32	16	Phila.	West'h'se	Direct	Voltage
Genco-Lite	A	22-73	1	4	3¼x3	W	2½	1200	110	32	16	Own	Own	Direct	......
	B	36-87	1	4	3¼x3	W	2½	1200	167	32	16	Own	Own	Direct	......
Langstadt-Meyer	B1½	75-160	4	4	3⅛x4½	W	...	1200	80-160	32	16	Willard	L.-M.	Direct	Throttle
	6	30-45	4	4	3⅛x4½	W	...	1200	80	32	16	Willard	L.-M.	Direct	Throttle
	6½	75	4	4	3⅛x4½	W	...	1200	80	32	16	Willard	L.-M.	Direct	Throttle
	7	100	4	4	3⅛x4½	W	...	1200	107	32	16	Willard	L.-M.	Direct	Throttle
Holt	....	30	1	4	......	W	...	....	86	110	56	Columbia	Own	Direct	Electric
Lauson	JR	15-40	1	4	3½x5	W	2	475	25	30	15	Edison	Own	Belt	Throttle
	202	16-50	1	4	4⅜x6	W	3	450	75	30	26	Edison	Own	Belt	Throttle
	203	27-154	1	4	5¼x7	W	4	425	112	30	26	Edison	Own	Belt	Throttle

Main-Lite	XX	12	1	4	......	W	1½	....	40	32	16	Own	Own	Belt	Throttle
	MAF	25	1	4	3¼x4½	W	1½	....	60	30	15	Own	Own	Belt	Throttle
	IBF	40	1	4	4½x8	W	3	....	80	30	15	Own	Own	Belt	Throttle
	2DF	50	1	4	4½x8	W	3	....	130	30	15	Own	Own	Belt	Throttle
Marco	....	85-100	1	4	......	..	4	....	32	32	16	Perfection	Dyneto	Chain	El. Magnetic
Matthews	A-1	50	1	4	......	W	3	....	80	32	16	Willard	G. E.	Direct	El. Mag.
	B	100	2	4	......	W	7	....	144	32	16	Willard	G. E.	Direct	El. Mag.
	B-1	100	2	4	......	W	7	....	144	32	16	Willard	G. E.	Direct	El. Mag.
	C	150	4	4	......	W	...	....	......	....	....	......	......	....	......
Mayhew	K-1	12-40	1	4	2¾x4	W	...	1400	80	32	16	......	Western	Direct	Cen'fugal
	K-2	16-48	1	4	2¾x4	W	...	1400	125	32	16	......	Western	Direct	Cen'fugal
	K-3	22-54	1	4	2¾x4	W	...	1400	160	32	16	......	Western	Direct	Cen'fugal
Perfection	SA1	50	1	4	3¼x3¼	W	3½	1150	80	32	16	Own	Dyneto	Direct	Voltage
	SA6	50	1	4	3¼x3¼	W	3½	1150	80	32	16	Own	Dyneto	Direct	Voltage
	SA10	50	1	4	3¼x3¼	W	3½	1150	80	32	16	Own	Dyneto	Direct	Voltage
Power-Lite	L-66	50-85	1	4	3¼x3¼	W	3½	1400	80-120	32	16	Prest-O-Lite	Imperial	Direct	Throttle
	L-72	50-120	1	4	3¼x3¼	W	3½	1400	160-240	32	16	Prest-O-Lite	Imperial	Direct	Throttle
	B-81	50-85	1	4	3¼x3¼	W	3½	1400	80-120	32	16	Prest-O-Lite	Imperial	Belt	Throttle
Rohaco	Unit	75	1	4	......	W	...	....	75-200	32	16-24	Prest-O-Lite	......	Direct	Flyball
	BE-1	50-120	1	4	......	W	...	....	75-125	32	16-24	Prest-O-Lite	......	Belt	Flyball
	BE-2	75	1	4	......	W	...	....	......	32	16-24	Prest-O-Lite	......	Belt	Flyball
Sunnyhome	....	62	1	4	2½x3	O	2½	2000	36	110	52	U. S. L.	Own	Direct	Suction
Swanlite	....	50-100	1	4	3x4	W	3	1100	60-160	32	16	......	......	....	......
Universal	1KW	75-120	1	4	......	W	...	....	90-130	32	16	......	Own	Direct	Mech.
	4KW	200	1	4	......	W	...	....	130	32	16	......	Own	Direct	Mech.
	M	75-100	1	4	......	W	...	....	120-165	32	16	......	Own	Direct	Mech.
Willys-Light	G. M.	85	1	4	2⅞x8½	W	2	1150	225	32	16	Exide	Auto-Lite	Direct	Suction
Wisconsin	15	12	1	4	4½x5½	W	3	450	36	26	13	......	Own	Belt	......
	30	24	1	4	4½x5½	W	3	450	36	32	16	......	Own	Belt	......
	50	40	1	4	5½x6	W	4	425	60	32	16	......	Own	Belt	......

W—Water. A—Air. O—Oil.

Nature and Measurement of Electricity.

It is of considerable importance to the farmer using an electric lighting plant and the numerous appliances which can be run from it, to have some idea of the properties of electricity and the system used in its measurement, and we are giving below a few simple definitions of the units of measurements.

Electricity is a form of energy, the exact nature of which is not known but for convenience in measurement it is assumed to act like a fluid in motion—having a pressure and rate of flow. It is often compared to water in a pipe which has pressure measured in pounds per square inch, and rate of flow in gallons per minute.

There are four principal units used in the measurement of electricity, as follows:

1. The Volt, or unit of pressure, which corresponds to pounds pressure, or feet of head.
2. The Ampere, or unit of rate of flow, which corresponds to gallons per minute.
3. The Ohm, or unit of resistance, which corresponds to the resistance of the pipe.
4. The Watt, or unit of power.

The current which flows in any direct current circuit is determined by the pressure behind the current and the amount of resistance in the circuit.

Thus: Current = Pressure ÷ Resistance
(In amperes) (In volts) (In ohms)

The foregoing equation is known as "Ohms Law" and it is undoubtedly the most used electrical equation known.

The power consumed in a circuit is equal to the product of the current and the voltage.

Thus: Power = Current × Pressure
(In watts) (In amperes) (In volts)

There are 746 watts in a horse-power; so the horse-power consumed in a circuit can be readily figured by dividing the watts by 746.

Thus: Horse-power = Power ÷ 746
(In watts)

The kilowatt is a larger unit sometimes used for convenience and is equal to 1,000 watts. Ampere hours and watt hours are simply units to measure the total current flow in a given time, or the power consumed in a given time, and are in each case obtained by multiplying the amperes or the watts by the number of hours the current is allowed to flow.

A 12-candle-power Mazda lamp operated on 32 volts takes about ½ ampere.

Therefore the power required to burn the lamp is: 32 × ½ or 16 watts.

If the lamp were burned for 10 hours a total of 160 watt hours would be consumed.

The capacity of a storage battery is measured in ampere hours and a battery of, say, 80 ampere hours capacity will burn one 12-candle-power lamp.

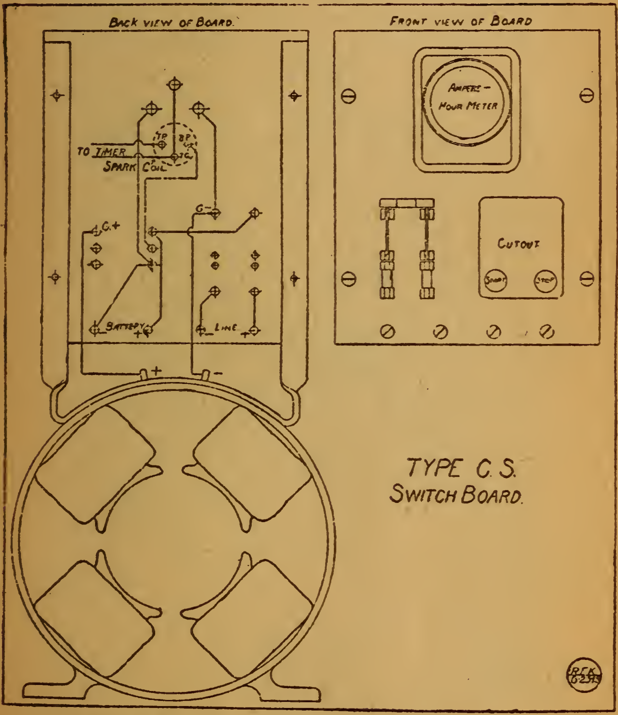
$80 \div \frac{1}{2} = 160$ hours,

or ten 12-C. P. lamps. $80 \div (10 \times \frac{1}{2}) = 16$ hours, etc.

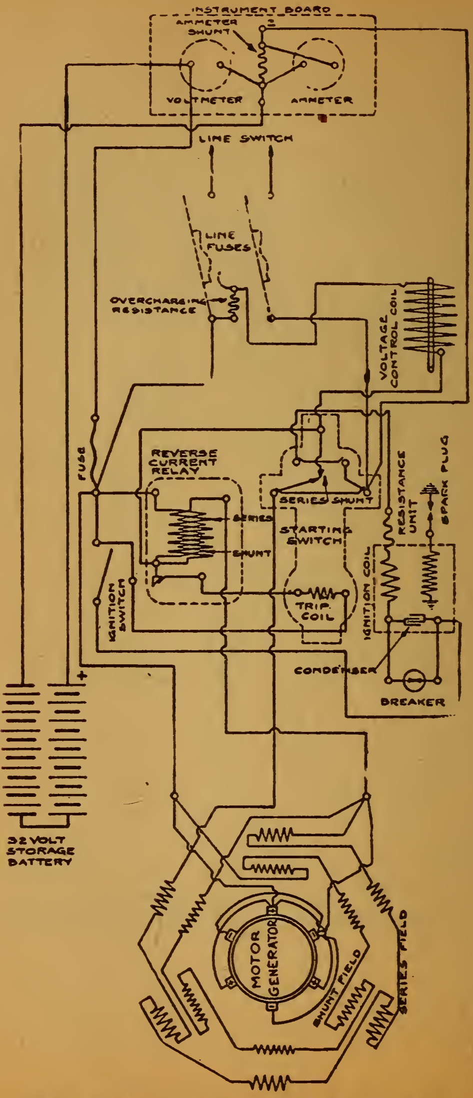
Specific Gravity Test Record.

Form suggested for use in making hydrometer readings of battery cells.

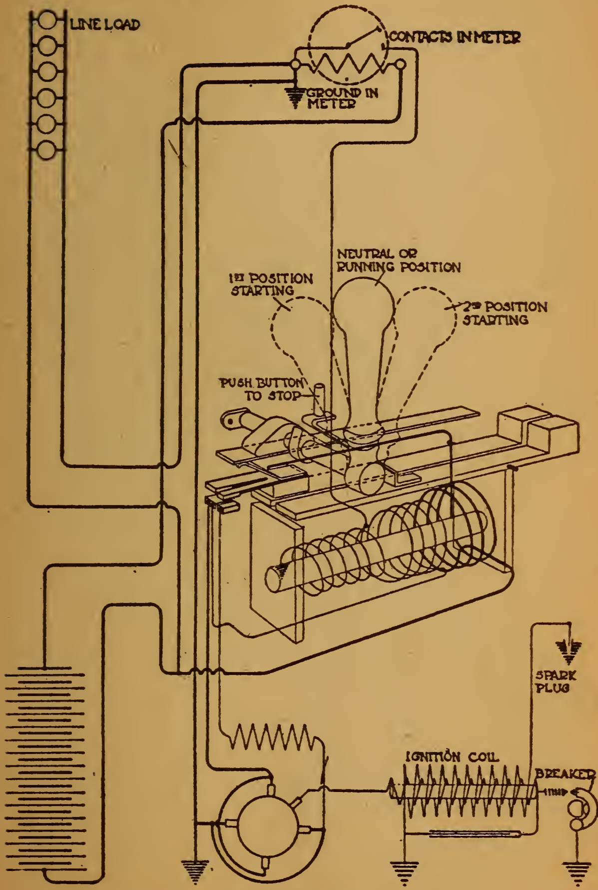
Cell No.	Specific Gravity at start of charge. Ampere Charging Rate, 15. Time, 8 A. M.	Specific Gravity. Time, 2 P. M. Ampere Rate, 10.	Specific Gravity. Time, 3 P. M. Ampere Rate, 10.	Specific Gravity. Time, 4 P. M. Ampere Rate, 10.	Specific Gravity. Time, 5 P. M. Ampere Rate, 10.
1	1200	1235	1240	1250	1250
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					



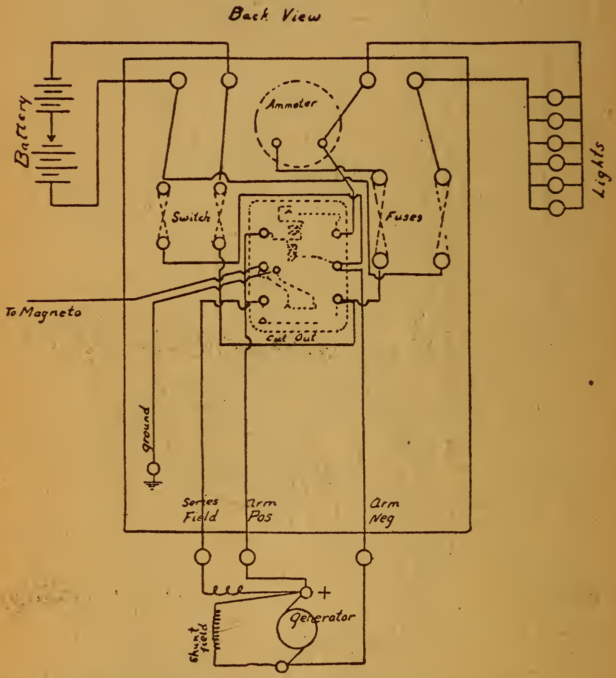
Wiring diagram of the Universal lighting plant.



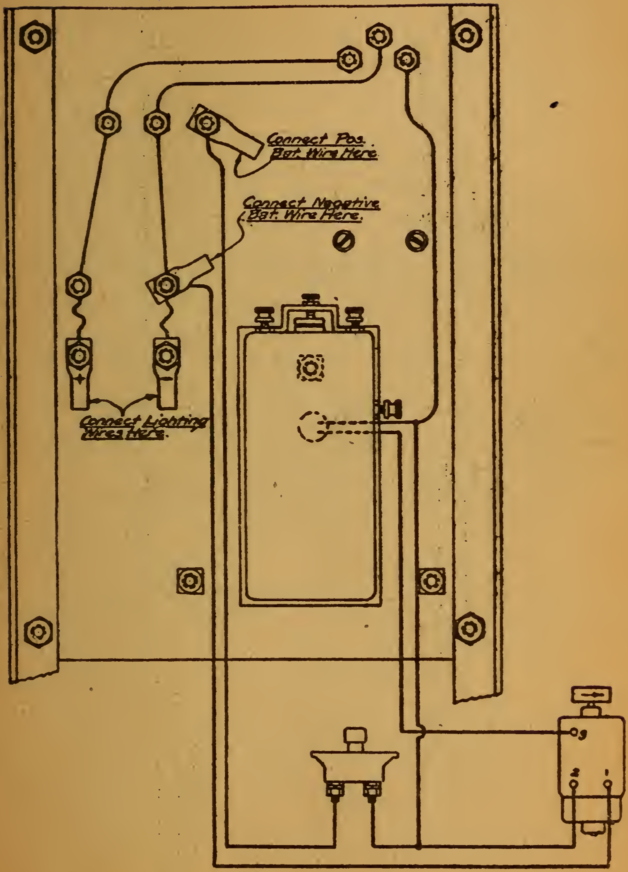
Wiring diagram of the Delco 3 K W lighting plant.



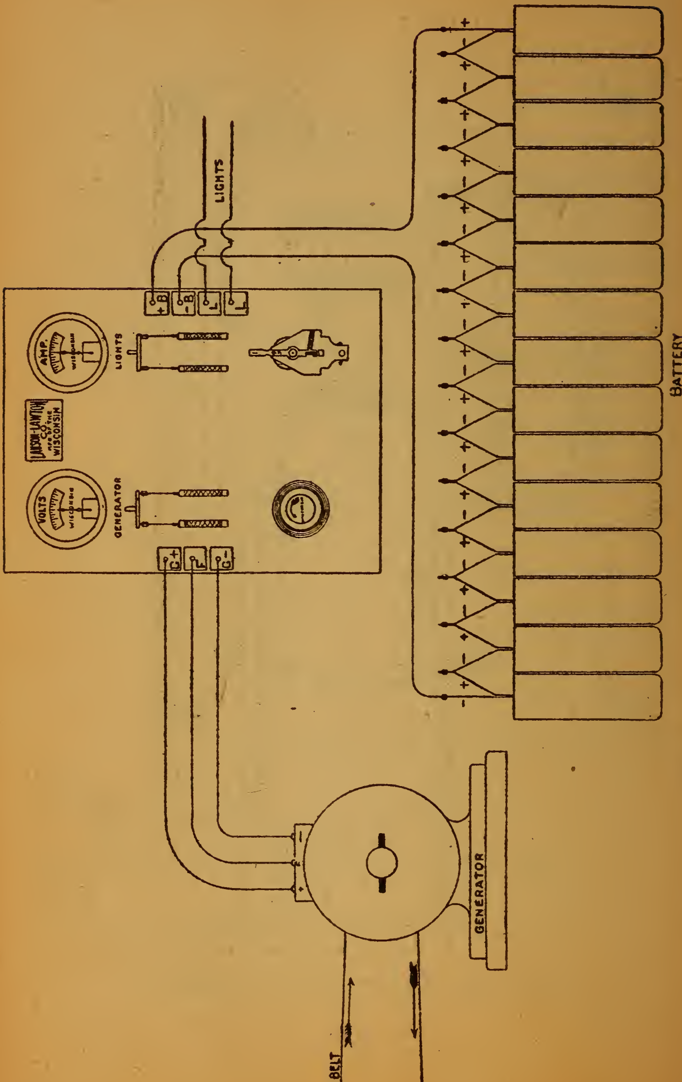
Wiring diagram of the Willys lighting plant.



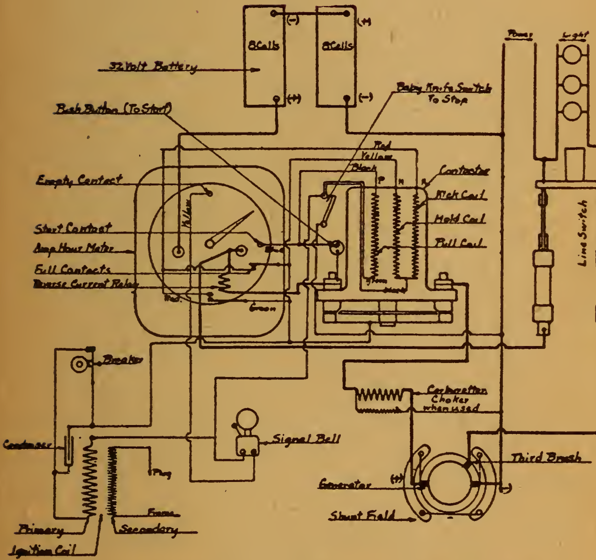
Wiring diagram of the Marco lighting plant.



Wiring diagram of the Dyneto lighting plant.



Wiring diagram of the Wisconsin lighting plant.



Wiring diagram of the Matthews lighting plant.